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ITS

STATISTICS, TECHNOLOGY & TRADE

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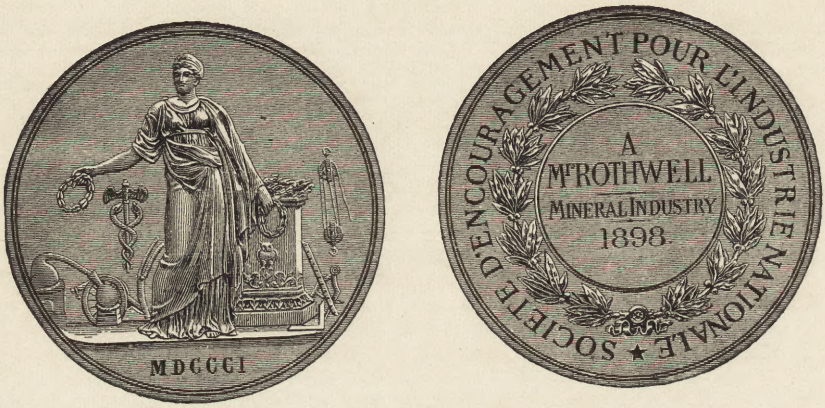
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TO THE END OF

1900.

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Linear. Inches to Millimeters.	Feet to Meters.	Yards to Meters.	Miles to Kilometers.		Capacity. Drams to Cubic Centimeters.	Ounces to Milliliters.	Quarts to Liters.	Gallons to Liters.	Cubic Inches to Cubic Centimeters.	Cubic Feet to Cubic Meters.	Cubic Yards to Cubic Meters.	Bushels to Hectoliters.
25.4000	0.304801	0.914402	1.60935	= 1 =	3.70	29.57	0.94636	3.78544	16.387	0.02832	0.765	0.35242
50.8001	0.609601	1.828804	3.21869	= 2 =	7.39	59.15	1.89272	7.57088	32.774	0.05663	1.529	0.70485
76.2001	0.914402	2.743205	4.82804	= 3 =	11.09	88.72	2.83908	11.35632	49.161	0.08495	2.294	1.05727
101.6002	1.219202	3.657607	6.43739	= 4 =	14.79	118.30	3.78544	15.14176	65.549	0.11327	3.058	1.40969
127.0002	1.524003	4.572009	8.04674	= 5 =	18.48	147.87	4.73180	18.92720	81.936	0.14158	3.823	1.76211
152.4003	1.828804	5.486411	9.65608	= 6 =	22.18	177.44	5.67816	22.71264	98.323	0.16990	4.587	2.11454
177.8003	2.133604	6.400813	11.26543	= 7 =	25.88	207.02	6.62452	26.49808	114.710	0.19822	5.352	2.46696
203.001	2.438405	7.315215	12.87478	= 8 =	29.57	236.59	7.57088	30.28352	131.097	0.22654	6.116	2.81938
228.6004	2.743205	8.229616	14.48412	= 9 =	33.28	266.16	8.51724	34.06896	147.484	0.25485	6.881	3.17181

Square. Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectaers.		Weight. Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds to Kilograms.	Troy Ounces to Grams.
6.452	9.290	0.836	0.4047	= 1 =	64.7989	28.3495	0.45359	31.10348
12.903	18.581	1.672	0.8094	= 2 =	129.5978	56.6991	0.90719	62.20696
19.355	27.871	2.508	1.2141	= 3 =	194.3968	85.0486	1.36078	93.31044
25.807	37.161	3.344	1.6187	= 4 =	259.1957	113.3981	1.81437	124.41392
32.258	46.452	4.181	2.0234	= 5 =	323.9946	141.7476	2.26796	155.51740
38.710	55.742	5.017	2.4281	= 6 =	388.7935	170.0972	2.72156	186.62089
45.161	65.032	5.853	2.8328	= 7 =	453.5924	198.4467	3.17515	217.72437
51.613	74.323	6.689	3.2375	= 8 =	518.3914	226.7962	3.62874	248.82785
58.065	83.613	7.525	3.6422	= 9 =	583.1903	255.1457	4.08233	279.93133

1 chain	=	20.1169	meters.
1 square mile	=	259	hectaers.
1 fathom	=	1.829	meters.
1 nautical mile	=	1853.27	meters.
1 foot=0.304801 meter,		9.4840158	log.
1 avoir. pound	=	453.5924277	gram.
15432.35639 grains	=	1	kilogram.

TABLES FOR CONVERTING METRIC TO UNITED STATES WEIGHTS AND MEASURES.

Linear. Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.		Capacity. Milliliters or Cubic Centiliters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Dekaliters to Gallons.	Hektoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
39.3700	3.28083	1.093611	0.62137	= 1 =	0.27	0.338	1.0567	2.6417	2.8375	0.0610	35.314	1.308
78.7400	6.56167	2.187222	1.24274	= 2 =	0.54	0.676	2.1134	5.2834	5.6750	0.1220	70.629	2.616
118.1100	9.84250	3.280833	1.86411	= 3 =	0.81	1.014	3.1700	7.9251	8.5125	0.1831	105.943	3.924
157.4800	13.12333	4.374444	2.48548	= 4 =	1.08	1.352	4.2267	10.5668	11.3500	0.2441	141.258	5.232
196.8500	16.40417	5.468056	3.10685	= 5 =	1.35	1.691	5.2834	13.2085	14.1875	0.3051	176.572	6.540
236.2200	19.68500	6.561667	3.72822	= 6 =	1.62	2.029	6.3401	15.8502	17.0250	0.3661	211.887	7.848
275.5900	22.96583	7.655278	4.34959	= 7 =	1.89	2.368	7.3968	18.4919	19.8625	0.4272	247.201	9.156
314.9600	26.24667	8.748889	4.97096	= 8 =	2.16	2.706	8.4534	21.1336	22.7000	0.4882	282.516	10.464
354.3300	29.52750	9.842500	5.59233	= 9 =	2.43	3.043	9.5101	23.7753	25.5375	0.5492	317.830	11.771

Square. Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.		Weight. Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.	Grams to Ounces Troy.
0.1550	10.764	1.196	2.471	= 1 =	15432.36	3.5274	2.20462	0.03215
0.3100	21.528	2.392	4.942	= 2 =	30864.71	7.0548	4.40924	0.06430
0.4650	32.292	3.588	7.413	= 3 =	46297.07	10.5822	6.61386	0.09645
0.6200	43.055	4.784	9.884	= 4 =	61729.43	14.1096	8.81849	0.12860
0.7750	53.819	5.980	12.355	= 5 =	77161.78	17.6370	11.02311	0.16075
0.9350	64.583	7.176	14.826	= 6 =	92594.14	21.1644	13.22773	0.19290
1.0850	75.347	8.372	17.297	= 7 =	108026.49	24.6918	15.43235	0.22505
1.2400	86.111	9.568	19.768	= 8 =	123458.85	28.2192	17.63697	0.25721
1.3950	96.874	10.764	22.2	= 9 =	138891.21	31.7466	19.84159	0.28936

The only material standard of customary length authorized by the U. S. Government is the Troughton scale, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound (5,760 grains) of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from

the British standard Troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter, and contains 7,000 grains troy.

The grain Troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois.

The British gallon = 4·54346 liters.

The British bushel = 36·3477 liters.

By the concurrent action of the principal Governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilograms were prepared, from the other a definite number of meter bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot to the different Governments and are called National prototype standards.

The metric system was legalized in the United States in 1866.

The International Standard Meter is derived from the Metre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogram is a mass of platinum-iridium deposited at the same place, and its weight *in vacuo* is the same as that of the Kilogramme des Archives.

The liter is equal to a cubic decimeter of water, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogram in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimeter.

Long ton: 2240 lb. avoirdupois	= 1016	kilogram.	Barrel of petroleum	= 42 gal.	= 1·59	hectoliter.	
Short ton: 2000 " "	= 907·2	"	" " salt	= 280 lb.	= 127	kilogram.	
Pound avoirdupois	= 453·6	grams.	" " lime	= 200 "	= 90·720	"	
Flask of Mercury = 76½ lb. avoir.	= 34·7	kilograms.	" " natural cement	= 300 "	= 136·080	"	
Troy ounce	= 31·104	grams.	" " Portland cement	= 400 "	= 181·440	"	
Gallon	= 3·785	liters.	Gold coining value per oz. Troy	$20·6718	= $0·6646	per gram.	
			Silver " " " Troy	$1·2929	= $0·04157	"	

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, APRIL 1, 1901.

Country.	Standard.	Unit.	Value in U. S. Gold.	Coins.
			cts.	
Argentina	Gold	Peso	96·5	Gold: argentine ($4·824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	20·3	Gold: former system—4 florins ($1·929), 8 florins ($3·858), ducat ($2·287), and 4 ducats ($9·149). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4·052) and 10 crowns ($2·026).
Belgium	Gold	Franc	19·3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	45·1	Silver: boliviano and divisions.
Brazil	Gold	Milreis	54·6	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
Canada	Gold	Dollar	100·0	
Central America				
Costa Rica	Gold	Colon	46·5	Gold: 2, 5, 10, and 20 colons ($9·307). Silver: 5, 10, 25, and 50 centimos.
British Honduras	Gold	Dollar	100·0	
Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	45·1	Silver: peso and divisions.
Chile	Gold	Peso	36·5	Gold: escudo ($1·825), doubloon ($3·650), and condor ($7·300). Silver: peso and divisions.
China	Silver	Tael*	74·2	
Colombia	Silver	Peso	45·1	Gold: condor ($9·647) and double condor. Silver: peso.
Cuba	Gold	Peso	92·6	Gold: doubloon Isabella, centem ($5·017). Alphonse ($4·823). Silver: peso.
Denmark	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Ecuador	Silver	Sucre	45·1	Gold: condor ($9·647) and double condor. Silver: sucre and divisions.
Egypt	Gold	Pound	494·3	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters.
Finland	Gold	Mark	19·3	Gold: 20 marks ($3·859), 10 marks ($1·93).
France	Gold	Franc	19·3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	23·8	Gold: 5, 10, and 20 marks.
Greece	Gold	Drachma	19·3	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas.
Haiti	Gold	Gourde	96·5	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions.
India	Gold	Pound†	486·65	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold	Lira	19·3	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire.
Japan	Gold	Yen	49·8	Gold: 5, 10, and 20 yen. Silver: 10, 20, and 50 sen.
Liberia	Gold	Dollar	100·0	
Mexico	Silver	Dollar	49·0	Gold: dollar ($0·983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Gold	Florin	40·2	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	Gold	Dollar	101 4	Gold: 2 dollars ($2·027))
Norway	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Persia	Silver	Kran	8·3	Gold: ½, 1 and 2 tomans ($3·409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold	Sol	48·7	Gold: libra ($4·8665). Silver: sol and divisions.
Portugal	Gold	Milreis	108·0	Gold: 1, 2, 5, and 10 milreis.
Russia	Gold	Ruble	51·5	Gold: imperial 15 rubles ($7·718) and ½ imperial, 7½ rubles ($3·859). Silver: ¼, ½, and 1 ruble.
Spain	Gold	Peseta	19·3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	19·3	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.
Turkey	Gold	Piaster	4·4	Gold: 25, 50, 100, 250, and 500 piasters.
United Kingdom	Gold	Pound	486·65	Gold: sovereign (pound sterling) and ½ sovereign.
Uruguay	Gold	Peso	103·4	Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	19·3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

* Haikwan (Customs). † The sovereign is the standard coin of India, but the rupee ($0·324) is the money of account, current at 15 to the sovereign.

RICHARD P. ROTHWELL.

THE death of Richard Pennefather Rothwell, the founder and editor of THE MINERAL INDUSTRY, was a sad occurrence which is here recorded as marking the opening of the year 1901. Of a life filled with great and useful achievement, Mr. Rothwell regarded the establishment and maintenance of this publication as his crowning work, which he often said would stand as his monument. For the originating and advancement of such an undertaking Mr. Rothwell had remarkable qualifications. His faithful study in early life at Trinity College, Toronto, the Rensselaer Institute at Troy, N. Y., and the Ecole Centrale des Mines at Paris; his professional practice in France and England, and his subsequent arduous and brilliant career as civil, mechanical and mining engineer in Pennsylvania, from the year 1866 to 1873; all were the fitting preparation for his later work as editor, writer and manager of statistical and scientific publications. Mr. Rothwell already was known as an accomplished writer on engineering and mining topics when, in 1874 he became an editor, and afterward the owner of *The Engineering and Mining Journal.* Later he formed The Scientific Publishing Co., and in 1893 began the publication of THE MINERAL INDUSTRY, which fulfilled his cherished ideal of an annual that would cover the whole field of the world's mineral production and the world's mining and metallurgical progress. Mr. Rothwell was eminently fitted to organize and advance this undertaking. He possessed a quick perception of the value of material for publication, an extraordinary memory and a keen sense of fitness and preparation. While he possessed in an eminent degree the power of broad generalization, few men could analyze a compilation of figures so quickly or give to statistical results so clear and compact a form. He laid the lines on which THE MINERAL INDUSTRY has been carried forward, and it is primarily due to his good judgment and management that the book from the first has possessed a value, both timely and permanent, which is generally acknowledged as scarcely without parallel in statistical and technical literature.

That he was one of the three founders of the American Institute of Mining Engineers; that he practically created *The Engineering and Mining Journal* as the recognized organ of the technical practice and the business interests of mining and metallurgy, and that he conceived and successfully established an undertaking so comprehensive and difficult as that of THE MINERAL INDUSTRY, is enough to indicate Mr. Rothwell's title to rank among the great leaders of professional progress. He received high recognition both at home and abroad, and the memberships in world-famous clubs and scientific societies that were conferred upon him were too numerous even to be indicated here. A token of honor and esteem peculiarly gratifying to him was the gold medal awarded him at the Paris Exposition, in 1898, by the Société d'Encouragement pour l'Industrie Nationale de France, as editor of THE MINERAL INDUSTRY.

Mr. Rothwell was born May 1, 1836, at Ingersoll, Ontario, Canada. He died at his residence in New York City, on April 17, 1901.



R. R. Rothwell



JOSEPH STRUTHERS.

CONTRIBUTORS.

It is impossible to name here all who have aided us in the collection of statistics and other information for the present volume, but we give in the following pages brief biographies of most of those who have contributed special articles, in order that readers may appreciate the high professional standing of those who have assisted in the work.

Besides the contributors of special articles, however, the preparation of this volume has been aided by the courteous co-operation of many thousands of producers who have furnished statistics of their output, and by many persons prominent in various branches of the mineral industry who have given special information. Exceedingly valuable assistance has been furnished also by the officials of many railways in the United States and Mexico, and by the State geologists, commissioners of mines, and inspectors of mines in most of the States of the Union. The statisticians of foreign countries have been extremely courteous in their co-operation, by furnishing copies of their latest publications, often in manuscripts. Professional men and experts of the whole world have rendered exceedingly valuable assistance, as have also the officials of the United States Government at Washington and abroad, and have added greatly to the value of this work. Among the thousands who have thus aided us, and by their assistance made possible the publication of this volume, as well as its predecessors, it would be invidious to select names, and in making such an attempt we should not know where to draw the line, since the contributions of almost all have been indispensable. Consequently we have decided to limit ourselves to this general acknowledgment, relying upon the belief that each of our friends will feel amply repaid for his work in the knowledge that he has contributed to the preparation of a volume which is everywhere recognized to be of the highest value to the mineral industry of the world. This high appreciation has been generously and delicately expressed by the French "Société d'Encouragement pour l'Industrie Nationale," which, since the appearance of Vol. VI., has granted to The Mineral Industry and its editor, the magnificent gold medal of the society, which is voted to the work or the author of the work, which, during the six preceding years, has contributed most to the cause of the national industry.

Adcock, S. R., was born in London in 1867, and studied at the City and Guilds of London, and the Birkbeck Institutes. As a chemist he went to Spain for the Rio Tinto Co. in 1888, and was its chief chemist in Spain from 1893 to 1899. At present he is engaged as manager to the St. Helens Smelting Co., Lancashire. He is a member of the Chemical and Mineralogical Societies, the Mining and Metallurgical Institution, and the Society of Chemical Industry, of London. Mr. Adcock contributes to this volume the paper, "The Action of Ferric Sulphate on Cupriferous Pyrites."

Addicks, Lawrence, was born in Philadelphia, Pa., in 1878. After spending a year in the shops and another at the University of Pennsylvania on special work he entered the Massachusetts Institute of Technology, where he was graduated in 1899, both in mechanical and in electrical engineering. After his graduation he went to Santa Rita, N. M., in the employ of the Santa Rita Mining Co., and from there, in 1900, to the Raritan Copper Works, at Perth Amboy, N. J., to the position he now holds of assistant to the superintendent. He contributes to this volume the paper, "The Raritan Copper Works."

Böhm, L. K., was born in 1859 in Thuringia, Germany. After studying and working with Dr. H. Geissler, in Bonn on the Rhine, he became assistant in 1879 to Thomas A. Edison, at Menlo Park, N. J., where he made the first incandescent lamps on exhibition at that place in December, 1879. In 1880 he was assistant to Hiram S. Maxim in the United States Electric Lighting Co., and he took out a number of patents in incandescent lighting. In 1881 he became electrician of the American Electric Light Co., and invented the separable incandescent lamp known as the stopper lamp. At the end of the

year he returned to Europe, where he studied for five years at different universities, graduating at Freiburg, where he received the degree of Doctor of Philosophy. Returning to America in 1887 he became experimental chemist for the American Ultramarine & Globe Aniline Works, and afterwards, for nearly a year, made researches on fossil resins for the Lawson Valentine Co. In 1889-90 he made experiments for the Thomson-Houston Co., at Boston, and later opened a laboratory in New York. During this period he fused carbon and lime by strong electric currents, obtaining calcium carbide, the first patent application being dated November 5, 1891. Dr. Böhm has been extensively employed as expert in electrical and chemical patent law suits, particularly in suits of the Edison Co., The Brush Swan Co., the Consolidated Co., the General Electric Co., and in many chemical patent law suits. As a writer he has contributed many articles to American and German electrical and chemical periodicals. To this volume Dr. Böhm contributes the paper, "Calcium Carbide and Acetylene."

CARPENTER, FRANKLIN R., was born in West Virginia. Educated as an engineer, with the degrees of M.A. and Ph.D., he began his mining work in the West Virginia coal and oil fields, and continued it in Colorado. In 1886, as Principal and Professor of Geology and Mining in the South Dakota School of Mines, he adapted the Kongsberg process of pyritic smelting to the South Dakota siliceous ores. For 10 years he was general manager of the Deadwood & Delaware Smelting Co. works, whose plant he designed and built. He designed also the plant for the Clear Creek Mining & Reduction Co., at Golden, Colo., of which company he is now general manager. Dr. Carpenter is a fellow of the Geological Society of America and of the American Institute of Mining Engineers. To the Institute he has contributed several papers, and other essays from his pen have treated of the geology and the mines of the Black Hills, and of pyritic smelting. To this volume Dr. Carpenter contributes the paper, "Pyritic Smelting."

CHANDLER, CHARLES FREDERICK, was born in 1836 at Lancaster, Mass. He studied at the Lawrence Scientific School, Harvard University; and at the Universities of Berlin and Göttingen, receiving from the latter the degrees of A.M. and Ph.D. (1856). In 1873 he received the degree of M.D. from the New York University and LL.D. from Union College, and in 1900 Oxford University conferred on him the degree of D. Sc. Dr. Chandler was president of the Centennial of Chemistry in 1874; the American Chemical Society, 1881 and 1889; the Health Department of New York City, 1867 to 1884; and the Society of Chemical Industry, 1899-1900. He was chemical editor of Johnson's Encyclopædia, and co-editor of the *American Chemist* from 1870 to 1877. Dr. Chandler has been professor of chemistry at Columbia University since 1864, a position he now occupies, and he is also professor of organic chemistry and president of the New York College of Pharmacy. He contributes to the present volume the paper, "Notes on Electro-Chemistry, 1900."

CLEMMER, JOEL G., was educated at the Central High School of Philadelphia, and afterward was in the employ of the Pennsylvania Salt Manufacturing Co. for 14 years, during which he acted as assistant to the superintendent of the works,—built its electrolytic copper plant, and made technical investigations concerning the various processes in use at Natrona. On leaving this company Mr. Clemmer established himself at Philadelphia as consulting engineer, making a specialty of chemical and electro metallurgical work. Mr. Clemmer has contributed articles to former volumes of THE MINERAL INDUSTRY, and to this volume he contributes the papers, "Recent Progress in the Henderson Process for Extracting Copper from Pyrites Cinders," and "The Manufacture of Blue Vitriol from Argentiferous Copper."

COOPER, A. S., the State Mineralogist of California, is a native of Maryland. He is an enthusiastic geologist who has successfully developed various mining enterprises in the southern part of California. For a quarter of a century he has given special attention to the study and examination of asphaltum and oil, and his library on this topic is said to be the most complete of its kind in the world. Mr. Cooper contributes to this volume the paper, "The Origin and Occurrence of Petroleum in California."

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



L. K. BÖHM.



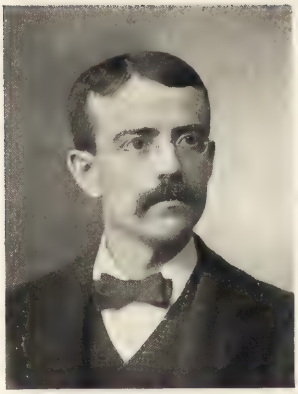
LAWRENCE ADDICKS.



FRANKLIN R. CARPENTER.



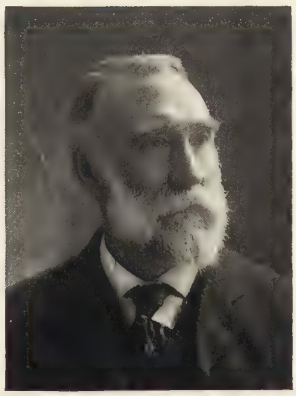
C. F. CHANDLER.



JOEL G. CLEMMER.



P. DVORKOVITZ.



JAMES DOUGLAS.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



AUGUST HECKSCHER.



F. J. FALDING.



H. O. HOFMAN.



HENRY MARION HOWE.



WALTER RENTON INGALLS.



EDWARD KELLER.



JOHN B. C. KERSHAW.

DOUGLAS, JAMES, was born in Canada, but has made his home in the United States since 1875. His first experience in mining and metallurgy was acquired in trying to unravel the complicated affairs of an unsuccessful Canadian mining enterprise. He came to the States in order to take charge of copper works established in Phœnixville, Pa., for the utilization of local copper ores, whose supply, however, proved deficient; but he is best known through his connection with the copper industry of Arizona, with which he has been intimately associated almost since its initiation. He is a past president of the American Institute of Mining Engineers, and president of the Copper Queen Consolidated Mining Co., and of other Arizona concerns, including the Arizona & Southeastern Railroad Co. Such original work as he has done was chiefly in connection with the late eminent chemist, Dr. T. Sterry Hunt, in the field of the hydrometallurgy of copper. Mr. Douglas has contributed to the present volume the notes on the copper industry in Arizona.

DRAKE, FRANK, was graduated from the Michigan College of Mines in 1890, and afterwards studied engineering and metallurgy at the Massachusetts Institute of Technology. He was employed at iron and copper mines in Michigan and at silver mines in Colorado until 1896, when he became superintendent of manganese mines in Russia for the Nicopol-Moriopol Mining & Metallurgical Co. While engaged with this organization he examined in its interest iron and manganese mines in various parts of Russia and the Caucasus. On returning from Russia in 1898 he became assistant manager of the War Eagle and Center Star gold-copper mines in British Columbia, resigning this position later to become chief engineer of the Oliver Iron Mining Co. Mr. Drake contributes to this volume the paper, "The Production of Manganese Ores in Foreign Countries."

DVORKOVITZ, PAUL, in 1877-78 was appointed sanitary chemist to the hospital of the Princess of Oldeburg in the Russo-Turkish war. Afterwards he studied chemistry at the University of Moscow, and in 1883 he took the position of technical manager of an oil refinery at Baku. There he discovered a method of utilizing the soda and acid by-products obtained in course of refining, and invented a special still for continuous distillation. Later, in England, Mr. Dvorkovitz worked to develop the use of solar oil for enriching water gas, and he invented an apparatus for gasifying oil and producing aromatic hydrocarbons. Five years ago he built for the Mineral Oils Corporation in London the first refinery in England, and prepared all the plans for another large refinery erected by the Shell Transport & Trading Co., Ltd., in Borneo. In 1899 he started the *Petroleum Review*, and in 1900, the *Oil World*. In 1900 Mr. Dvorkovitz was instrumental in forming the petroleum congress in Paris, in August, which resulted in the establishing of a permanent commission for organizing international petroleum congresses every two years in the future, with a central committee in Paris, and local committees all over the world. Mr. Dvorkovitz contributes to this volume the paper, "Petroleum."

FALDING, F. J., was born in England and was educated at Amersham Hall, London, and at the Bergakademie at Freiberg in Saxony, although he did not graduate from the latter. In 1878-79 he made a study of the Canadian apatite deposits, and in 1880 returned to Europe, where he studied the manufacture of sulphuric acid and fertilizers in England and Germany. In 1881 he returned to Canada and unwatered the Capelton pyrites mines, now worked by the Nichols Chemical Co. From 1882 to 1886 he practiced as a mining engineer, with headquarters in New York, making a specialty of pyrites and phosphate mining. In 1888 he entered the employ of the Graselli Chemical Co. as engineer, in charge of its mines, becoming in 1890 the chief engineer. During this time he designed the company's new works at East Chicago, Ill. In 1889 he was one of the charter members and first directors of the Canadian Institute of Mining Engineers. In 1895 he established himself in New York as a consulting chemical engineer, since which time he has constructed and rebuilt many sulphuric acid plants in various parts of the United States. He contributes to this volume the paper, "Progress in the Sulphuric Acid Industry in 1900."

HECKSCHER, AUGUST, was born at Hamburg, Germany, and educated in Germany and Switzerland. He was actively connected with the anthracite coal mining industry in the United States from 1868 to 1882, and since 1881 he has been engaged in the zinc mining and manufacturing industry in New Jersey, Pennsylvania, Illinois, Wisconsin and Missouri. At present he is general manager of the New Jersey Zinc Co. Mr. Heckscher contributes to this volume the review notes on the zinc industry of New Jersey.

HOFMAN, H. O., was born in 1852 at Heidelberg, Germany. He studied at the Bergakademie at Clausthal, where he graduated in 1877 in mining engineering and metallurgy. He was then appointed chemist and assistant at the smelting and refining works at Lautenthal in the Harz. In 1881 he came to the United States and was employed successively at Mine La Motte, in Missouri, at the Argentine smelting and refining works of the Consolidated Kansas City Smelting & Refining Co., and as metallurgist of the Delaware Lead Co., in Philadelphia. When the last named works were closed he went to Colorado, and after running the Rico smeltery for a short time went to Park City, Utah, to study the amalgamation and lixiviation of silver ores at the Ontario mill. After a short time spent in charge of a smeltery in Mexico he was appointed assistant to Prof. Richards at the Massachusetts Institute of Technology in Boston; from there he went to the School of Mines of South Dakota as professor of metallurgy and assaying, where he remained until called back to the Massachusetts Institute of Technology to the professorship of metallurgy, which he now holds. Dr. Hofman has made numerous contributions to technical literature, his most important work being the admirable treatise on *The Metallurgy of Lead.* For his paper on the "Dry Assay of Tin Ores" the degree of Ph.D. was conferred on him by the University of Ohio. For the present volume he has reviewed the progress in the metallurgy of lead, continuing the series of articles begun in the first volume.

HOWE, HENRY M., graduated at Harvard College in 1869, and at the Massachusetts Institute of Technology in Boston in 1871, paying especial attention while at the latter institution to the metallurgy of iron and steel. In 1872 he became superintendent of the Bessemer steel works at Joliet, Ill., and, until 1883, he was actively engaged in metallurgical manufactures, chiefly of iron and steel. From then until the present time he has been a consulting metallurgist, attending almost exclusively to the metallurgy of iron and steel. For a number of years Mr. Howe was lecturer at the Massachusetts Institute of Technology, and is now professor of metallurgy at Columbia University School of Mines. In 1895 the Franklin Institute of Philadelphia awarded him the Elliott Cresson gold medal for his researches on the nature and properties of iron and steel, and in the same year, the Iron and Steel Institute of Great Britain awarded him its Bessemer gold medal in recognition of his scientific contributions to metallurgical literature; the French Société d'Encouragement pour l'Industrie Nationale awarded him a prize of 2,500 francs for his monumental treatise on the *Metallurgy of Steel,* which, besides running through several American editions, has been translated and published in French. In addition, the Verein zur Befoerderung des Gewerbfleisses of Berlin awarded him its great gold medal for scientific research. Mr. Howe is a member of many scientific and technical societies in the United States and Europe, past president of the American Institute of Mining Engineers, Chevalier of the Legion of Honor of France, member of Council of the International Association for Testing Materials, and Chairman of its American section. He was also president of the jury on "Mines and Mining" at the World's Columbian Exposition in Chicago in 1893. For this volume Professor Howe has contributed the paper, "A Report on Iron and Steel Metallurgy at the Paris Exposition, 1900."

HYDE, F. S., was educated at the Brooklyn Polytechnic Institute, and in 1893 was graduated from the Columbia School of Mines in the course of chemistry. Later he was engaged in experimental investigations in decorative glass for L. C. Tiffany, and in May, 1894, he was appointed Assistant Chemist to the Brooklyn Health Department, being detailed on food and water supply, a position he filled until 1898. For two years after this Mr. Hyde was Assistant in Analytical Chemistry at Columbia University, and since

June, 1899, he has been connected with the Joseph Dixon Crucible Company, Jersey City. Mr. Hyde has written several technical articles, and has contributed to the present volume the paper, "Assay of Graphite by Blast and by Fusion."

INGALLS, WALTER RENTON, a well-known mining engineer and metallurgist, was born at Lynn, Mass., in 1865, and graduated from the Massachusetts Institute of Technology, in 1886. In 1886-90 he was engaged in mining at Leadville and elsewhere in Colorado. In 1890-92 he was assistant editor of the *Engineering and Mining Journal*, resigning that position to go to Mexico to open tin mines in the State of Durango for the Pittsburg & Mexican Tin Mining Co. In 1893 and 1894 he established himself in New York, and visited professionally various mining districts in the United States, Canada, Belgium, Germany and Poland, devoting himself especially to the metallurgy of zinc. During a part of 1894 he had charge of the operations of the Illinois Phosphate Co., in Florida, and later in the year became connected with the Gold & Silver Extraction Co. of America, Ltd., as metallurgist. In 1895 he was manager of a cyanide works at Cripple Creek, Colo., and in 1896 of copper-matte smelting works in Durango, Mexico, returning to New York in 1897. He was assistant editor of THE MINERAL INDUSTRY, Vols. V., VI. and VII., and is now located in Boston, Mass., as consulting engineer. For this volume he contributes the paper, "The Progress in the Metallurgy of Zinc in the United States during 1900."

JANIN, LOUIS, JR., was born in Virginia City, Nev. He attended the University of California, and later entered into active work in the gold mines of that State. He was metallurgist of the Ontario Silver Mining Co., at Park City, Utah, where he made the first recorded experiments on any scale with potassium cyanide as a means of extracting gold and silver, and for many years he was engaged professionally in examining mines in various parts of the United States, Mexico, Central and South America. In 1894 he became connected with the various companies controlling the MacArthur-Forrest cyanide patents, and in this connection made a long visit to Australia, where he became interested in mining, and acted as consulting engineer or general manager for various companies, notably copper-gold mines at Cobar, N. S. W. Mr. Janin has been a frequent contributor to the *Engineering and Mining Journal*, and at one period was assistant editor of that journal. To Vol I. of THE MINERAL INDUSTRY he contributed an article on "The Cyanide Process," which was the first comprehensive one published on that subject, and to Vol. II. a thorough article on "The Amalgamation of Free-Milling Gold Ores." For the present volume he contributes the paper, "Progress in the Cyanide Process in 1900."

KELLER, EDWARD, was born at Sauk City, Wis., in 1857, and studied chemistry and the allied sciences at Stuttgart in Germany and Zurich in Switzerland, taking the degree of Ph.D. at the latter university. Ill health compelled him to go to the Rocky Mountains, and while there he took up metallurgical chemistry, and subsequently studied at the Colorado School of Mines and at Freiberg in Saxony. He then spent four years at Butte, Mont., in connection with the smelting works of W. A. Clark and the Parrot Silver & Copper Mg. Co. Since 1893 he has been metallurgical representative of the Anaconda Copper Mining Co., at the Baltimore Copper Works, where half of the former company's output is refined electrolytically and its whole output is brought into marketable shape. Dr. Keller contributes to this volume the paper, "The Elimination of Impurities from Copper Mattes."

KERSHAW, JOHN B. C., was born at Southport, Eng., and was educated at Bickerton House School, Southport, and at Owens College, Manchester. In 1879 Mr. Kershaw entered the Sutton Lodge Chemical Works, St. Helens, Eng., and remained there for twelve years, rising in this period to the position of chief chemist and assistant manager. In 1892 Mr. Kershaw went to Germany and pursued his studies of chemistry and allied sciences at Bonn University. Since 1896 he has been engaged in practice as consulting chemist and as a technical journalist in London, and has devoted himself especially to work relating to electro-chemical processes and industries. He is a member of several

chemical and other societies, and is also on the staff of abstractors for *The Journal of the Society of Chemical Industry* and for *Science Abstracts*. Mr. Kershaw has written numerous articles in recent years upon electro-chemical and electro-metallurgical subjects, and is the translator and editor of Dr. Neumann's German work on *Electrolytic Methods of Analysis*. To the present volume he contributes the articles, "Progress in the Aluminum Industry in 1900," "The Manufacture of Potassium Chlorate by the Liebig Process," "Progress in the Electrolytic Alkali and Chlorine Industry during 1900," and "Potassium and Sodium Chlorates and Hypochlorites in 1900."

KLOCKMANN, FRIEDRICH, was born in 1858 at Schwerin, Mecklenburg, and studied at the Bergakademie of Clausthal and the Universities of Berlin and Rostock. In 1882 he was made associate in the Royal Prussian Landesanstalt at Berlin, and in 1887 he succeeded Prof. von Groddeck as professor of geology and mineralogy in the Clausthal Bergakademie. Later he accepted a call to the technical school at Aix-la-Chapelle. Dr. Klockmann has published numerous works relating to mineralogy, geology, and the theory of ore deposits, among them a text book on mineralogy which has found wide recognition in Germany and other countries, and is now in its second edition. To the present volume he has contributed the article, "Geology and Technology of the Potassium Salts Industry of Germany."

KRUSCH, PAUL, was born in 1869 at Goerlitz, Silesia, and after passing the State examination he entered upon the career of a mining engineer. He studied at the Universities of Leipzig and Berlin, and at the Bergakademie in the latter city, and in 1894 he was made Royal Bergreferendar. Shortly afterward he entered the Royal Geological Landesanstalt and Bergakademie at Berlin as geologist, with which he is now connected. In 1895 he received the degree of Doctor of Philosophy at Leipzig for a thesis on basalts. He has made a special study of ore deposits, and is one of the editors of the *Zeitschrift für praktische Geologie*. Dr. Krusch contributes to the present volume the paper, "The Utilization of Lignite in Germany."

LANE, ALFRED C., was graduated from Harvard College in 1883, and, two years later, went to Europe, where he remained over two years at Heidelberg, studying geology. On his return to America, after taking the degree of Ph.D. at Harvard, he was employed by the U. S. Geological Survey, and in February, 1889, was sent to Houghton, in the Lake Superior copper country. He remained connected with the Geological Survey until 1893, when he became assistant State geologist, and afterwards was appointed State Geologist of Michigan. Dr. Lane's work, so far as it appears in State reports, is in the 1891-92 report of the Board, Part II. of Vol. V. and Part I. of Vol. VI. He has contributed extensively both to scientific journals and to popular periodicals. For the present volume of THE MINERAL INDUSTRY he contributes the paper, "The Production of Bromine in Michigan."

LENHER, VICTOR, was graduated in chemistry in 1893 from the University of Pennsylvania, and for three years following he was assistant to Prof. W. B. Rising in the chemical department of the University of California. From 1896 to 1898 he was engaged in pursuing special studies in chemistry, mineralogy and geology at the University of Pennsylvania, receiving the degree of Ph.D. from that institution in 1898. Dr. Lenher has been a regular contributor to various chemical journals. He was on the staff of instruction in chemistry at Columbia University from 1898 to 1900, and is at present assistant professor of general and theoretical chemistry at the University of Wisconsin. He contributes to this volume the article, "Rare Elements."

LEWIS, FREDERICK H., studied civil engineering at the University of Pennsylvania, graduating in 1878. He then became heliotroper on the United States Coast Survey, serving during the summer of 1878, and for three years afterwards was assistant engineer of the construction department of the Pennsylvania Railroad Co.'s lines west of Pittsburg. From 1882 to 1885 he was superintendent of bridges and buildings of the Northern Pacific Railway, being situated at St. Paul, Minn., and he was also in charge of the location of the company's terminal lines between St. Paul and Minneapolis. In 1885 and 1886 he was

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



PAUL KRUSCH.



F. KLOCKMANN.



VICTOR LENHER.



F. H. LEWIS.



ROBERT LINTON.

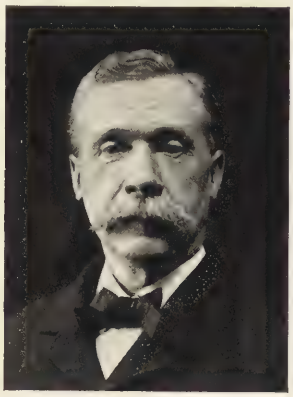


FRANK OWEN.



G. LUNGE.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



ROBERT H. RICHARDS.



R. W. RAYMOND.



H. RIES.



A. J. ROSSI.



JOHN E. ROTHWELL.



ALBERT SAUVEUR.



HENRY E. SOUTHER.

resident engineer of the South Pennsylvania Railroad, at Sideling Hill tunnel, Fulton County, Pa. From 1886 to 1893 he was an Eastern manager of the Pittsburg Testing Laboratory at Philadelphia. Since 1893 he has been practicing as consulting engineer at Philadelphia, and has also been consulting engineer for the firm of Booth, Garrett & Blair, in their department of physical tests and inspection. He is now manager and chief engineer of the Virginia Portland Cement Co., and contributes to this volume the paper on "The Hydraulic Cement Industry in the United States in 1900."

LINTON, ROBERT, was born at Hudson, O., in 1870. He was educated at Washington and Jefferson College, Washington, Pa., and at the Royal Polytechnic School, Berlin. He was engaged for a time in mining engineering in the Pennsylvania bituminous region near Pittsburg, Pa., and later entered the employ of the R. C. Schmertz Glass Co., continuing with them until the formation of the American Window Glass Co. At present Mr. Linton is manager of the works of the latter company at Belle Vernon, Pa. He is a member of American Institute of Mining Engineers, and has written many articles for technical publications, contributing to the present volume the paper on "Glass."

LUNGE, GEORGE, was born in 1839 at Breslau, Silesia. He studied at the University of Breslau, where he received the degrees of M.A. and Ph.D., continuing his work later at Heidelberg under Bunsen and Kirchhoff. In 1864 he went to Great Britain, where he became chemist and later superintendent of the coal tar and ammonia works at Wolverhampton. From 1865 until 1876 he was connected with the sulphuric acid and alkali works at South Shields, after which he succeeded Emil Kopp at the Swiss Federal Polytechnic School at Zurich, where he is now professor of technological chemistry. Dr. Lunge has contributed to technical literature several of its most important works, which include his "*Coal Tar and Ammonia*," "*Manufacture of Sulphuric Acid and Alkali*," "*Alkali Makers' Handbook*" and "*Chemisch-Technische Untersuchungsmethoden.*" Dr. Lunge has written extensively on various subjects of pure and applied chemistry, and he contributes to this volume the papers, "The Manufacture of Water Gas," and "The Utilization of Blast Furnace Gas for the Direct Production of Power."

MCILHINEY, PARKER C., was born in 1870 at Jersey City, N. J., and in 1892 he was graduated from the School of Mines, Columbia College, in the course of chemistry, receiving in 1894 the degree of Ph.D. for special work in chemistry and physics. From 1894 until 1900 he was connected with the Departments of Chemistry and Metallurgy, Columbia University, and, in addition to general chemical practice he has given considerable time to the manufacture of glass, metal, enamel and pottery art works. Dr. McIlhiney contributes to this volume the paper, "The Manufacture of White Lead."

MACKAY-HERIOT, E. C., was born at Bath, England, in 1874, and at the age of 17 he began his professional studies at the Royal Acadamie of Mines, Clausthal, where he gained practical experience as a working miner. In October, 1896, he took the position of assistant superintendent of the ore dressing plant of the Almaraz Tin Mining and Smelting Co., in Spain, and later he was installed as local superintendent of the San Martinho Tin Mine, in Portugal. In April, 1898, he was placed in local charge of a company exploiting for potash salts near Hanover, and later was transferred to Bleicherode a. Harz, to act in a similar capacity. Mr. Mackay-Heriot contributes to this volume the paper, "Statistics of the Potassium Salts Industry of Germany."

MEMMINGER, C. GUSTAVUS, was born at Charleston, S. C., in 1864, and began work as mining engineer in the phosphate industry of South Carolina. He took an active part in the mineral development of the South, and when the Florida phosphate deposits were opened he was prominent in the furthering of the new industry there. After building and successfully operating the largest pebble phosphate mining plant in Florida, Mr. Memminger, in 1900, moved to Nashville, Tenn., where he is now engaged in engineering and chemical work. Mr. Memminger contributes to this volume the paper, "Progress in the Phosphate Mining Industry in the United States during 1900."

NEWLAND, DAVID H., was graduated from Hamilton College in 1894, and for three years thereafter was a student of geology and related sciences at the Universities of Munich, Heidelberg, and Columbia. In 1897 and 1898 he was employed by the State of New York

mapping the geology of portions of the Adirondack mountains, the results of this work appearing recently in the 18th Annual Report of the State Geologist. He has been engaged from time to time in other geological investigations, particularly in determining the petrographical relations of metamorphosed rocks, and has contributed to scientific journals. For the past two years Mr. Newland has been connected with THE MINERAL INDUSTRY as assistant on the editorial staff.

OBALSKI, J., was born in France in 1852, and studied at the Ecole des Mines at Paris; after graduation he occupied several positions in connection with the mining industry in France and Spain, and visited various mining districts in those countries and Belgium and Portugal. In 1881 he was called by the government of the Province of Quebec to fill the position of mining engineer and inspector of mines, which post he still occupies. He has contributed to the present volume notes on asbestos, chrome ore, copper ore, and mica mining in Quebec.

OWEN, FRANK, was born at London, Eng., in 1869, was educated at the Whitgift School, Croydon, Surrey, and afterwards studied with eminent mining engineers and chemists. Mr. Owens was for some years engaged in gold mining in Columbia and Venezuela, and later visited Mexico, South Africa, Australia, Norway, Spain and the United States. He resided for some time in the Malay Peninsula, where he was engaged in hydraulic tin mining, and he devoted much study to the tin deposits of that region. Mr. Owen is an associate member of the Institution of Civil Engineers, London, and is a member of the American Institute of Mining Engineers. To this volume he contributes the article, "A Review of the Tin Industry in the Malay Peninsula."

RAYMOND, ROSSITER WORTHINGTON, who is well known as a high authority on mining law, for many years was the editor of the *Engineering and Mining Journal*, and was practically its founder. He was for several terms president of the American Institute of Mining Engineers, and for many years has been its efficient secretary. Educated as a mining engineer at Freiberg, Saxony, he quickly became one of the most prominent engineers in America, and was influential in the framing of the early mining laws of the United States. As United States Commissioner of Mining, from 1868 to 1876, he contributed much to the scientific discussion of ore deposits, and his translations of the treatise of Posepny, Vogt and others have won for him a wide recognition among the students of this science. To this volume Dr. Raymond contributes the paper, "Recent Contributions to the Science of Ore Deposits."

RICHARDS, ROBERT HALLOWELL, professor of mining and metallurgy at the Massachusetts Institute of Technology, was born in 1844 at Gardiner, Me. He graduated in 1868 from the Massachusetts Institute, being a member of its first class, and became assistant in chemistry in the corps of instruction, passing successively to the posts of instructor, assistant professor of chemistry, professor of mineralogy and assaying, professor of mining engineering, and in 1884 to his present professorship of mining and metallurgy. Under his administration the mining and metallurgical laboratory, which was the first of its kind in an educational institution, has been developed to a high degree of excellence, and has been a model for similar laboratories in other colleges. In addition to his professional duties, Prof. Richards has been actively engaged as a consulting engineer in mining and metallurgical work, and has been the inventor of several ingenious devices, which have found extended use in practice. He has contributed many valuable papers to the technical press, and to the transactions of various scientific societies. His most recent work on the principles of ore dressing is the admiration of the entire body of engineers engaged in that branch of metallurgy. To this as in previous volumes he has contributed the comprehensive review, "Progress in Ore Dressing."

RIES, HEINRICH, Ph.B., A.M., Ph.D., was graduated in 1892 from Columbia College, School of Mines, New York City. After his graduation he was employed as assistant geologist on the New York State Geological Survey, and during the World's Fair at Chicago he was assistant director of the New York scientific exhibit. He has prepared much valuable data on the clays of New York State, and in a special trip made to Europe

to investigate the foreign clay-working industry, he studied at the University of Berlin the German methods for the laboratory investigation of clays. In 1895 he was judge of clays at the Cotton States Exhibition. Dr. Ries has traveled extensively in the mining regions of the United States and Europe in connection with private and government work, has written a number of papers on economic geology, and has prepared special State reports on the clays of New York, Michigan, Alabama, North Carolina, Louisiana and Maryland. Since 1898 he has been instructor in economic geology in Cornell University, Ithaca, N. Y., and also he is an associate editor of the *Geologische Centralblatt.* To this volume Dr. Rises contributes the paper, "Clay and Its Manufacture into Brick and Tile."

ROSSI, AUGUSTE J., was born in Paris in 1842. In 1858 he was graduated from the University of France, and he received his degree of civil and mining engineer from the Ecole Centrale in 1861. Soon afterward he came to the United States, of which he has long been an adopted citizen. Mr. Rossi, in the course of his professional practice, has been with the Morris & Essex Railroad, with the Boonton blast furnaces and with the New York Ice Machine Co. For the past eight years he has devoted himself particularly to electro-metallurgy, and as consulting mining engineer has been engaged in the study of the metallurgy of titanium. He is a member of the American Institute of Mining Engineers and of the American Chemical Society, and various articles from his pen have appeared in the published proceedings of these societies, and in other technical publications. To this volume Mr. Rossi contributes the paper, "The Manufacture of Titanium and Its Alloys."

ROTHWELL, JOHN E., was born at Kingston, Ontario, in 1865. He acquired his knowledge of mining and milling by practical experience, beginning in the machine shops attached to a mine and mill in Canada, and subsequently working his way up gradually to be superintendent of the plant while still only a youth. He was afterwards engaged under the late John Heard, at the works of the Brunswick Antimony Co., near Boston, Mass. He then went to Deadwood, S. D., in 1890, where he remodeled and afterwards managed with great success the mill of the Golden Reward Co., using barrel chlorination. Subsequently he built several mills in Nevada and Colorado. Although experienced both in mining work and as a mechanical engineer, Mr. Rothwell has made a specialty of the roasting and treatment of refractory gold ores, making an excellent record for successful and economical work. He has made many inprovements in chlorination plants and processes, and has contributed valuable papers on the subject to technical periodicals. Mr. Rothwell contributes to this volume the paper, "The Present Development of the Barrel Chlorination Process."

SAUVEUR, ALBERT, studied four years at the Ecole des Mines at Liége, Belgium, and then at the Massachusetts Institute of Technology, where he was graduated in 1889. After one year in the chemical laboratory of the Pennsylvania Steel Co., at Steelton, Pa., he became connected with the South Chicago works of the Illinois Steel Co., with which he remained six years, most of the time in charge of the experimental laboratory. Since February, 1897, he has been proprietor and manager of the Boston Testing Laboratories at Boston, and is now assistant professor at Harvard University, lecturer at the Massachusetts Institute of Technology, and editor of *The Metallographist.* Mr. Sauveur is a member of several scientific societies, and has been a contributor to numerous technical publications. He has a world-wide reputation as an expert in his specialty, the investigation of the micro-structure of metals, and its bearing upon their technology. Mr. Sauveur contributes to this volume the paper, "The Progress in Metallography in 1900."

SOUTHER, HENRY, was born in Boston, Mass., in 1865, and received his early education in the public schools of that city. He graduated from the Massachusetts Institute of Technology, in 1887, in mining and metallurgy, and spent the following year at Clausthal, Germany, returning to the United States in 1888, to accept a position in the Bessemer and open-hearth departments of the Pennsylvania Steel Co., at Steelton. Pa. In 1893 he entered the employ of th Pope Mfg. Co., at Hartford, and built the laboratory for chemical and physical tests, resigning in 1899 to establish himself as a consult-

ing engineer at Hartford, Conn. Mr. Souther contributes to the present volume the paper, "Alloys of Iron."

STRUTHERS, JOSEPH, was born in New York City, and attended the School of Mines, Columbia College (now Columbia University), graduating therefrom in chemistry in 1885, and in 1895, receiving the degree of Ph.D. from that institution. For three years after his graduation he was assistant in the department of mineralogy at Columbia University, and from thence until 1900 he was on the staff of instructors of the department of metallurgy, first assisting Dr. Thomas Egleston, and later Prof. Henry M. Howe. He is now honorary lecturer in metallurgy at Columbia University. In 1896 he organized and conducted the first summer school in practical metallurgy of Columbia University, which was held at Butte, Mont., and, in the following year, the summer schools at Chicago and Pittsburg were under his charge. In 1898 and 1899 he assisted at the summer schools held in Pennsylvania and Maryland. Dr. Struthers has visited many metallurgical plants in the United States and in Europe, and he has carried on special investigations in calorimetry, measurement of furnace temperatures, microscopical examination of metals and slags, and work of like character. He has written numerous articles for the *School of Mines Quarterly*, and from 1892 to the present time he has been on its Board of Editors, acting for most of this period as business manager. As assistant editor of THE MINERAL INDUSTRY, Vols. VIII. and IX., he has had entire charge of their preparation, and has contributed to them many unsigned articles.

ULKE, TITUS, was born in 1866, at Washington, D. C. In 1889 he was graduated from the Royal School of Mines at Freiberg, Saxony, as metallurgical engineer. After spending some time in visiting the various mines and metallurgical works in Europe, Mr. Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Co., in South Dakota. In 1891 he became assayer for the United Smelting Co., and afterwards was engaged by the Anaconda Mining Co., as chemist at its electrolytic copper refining works. In 1893 Mr. Ulke acted as metallurgist to the Mines and Mining Department of the Chicago Columbian Fair, and was later employed at the Guggenheim works at Perth Amboy, N. J. As triangulator for the U. S. Geological Survey in 1897, he had charge of a party to survey the Montana timber reserves, from which he returned to continue work in his specialty—the electrolytic production of copper, nickel, gold and silver. Soon after the declaration of war with Spain, Mr. Ulke was appointed Assistant Inspector of Ordnance, U. S. A., which position he resigned in 1900 to become metallurgical engineer to the Lake Superior Power Co., Sault Ste. Marie, Ont. Mr. Ulke has contributed to the present volume the papers, "Progress in the Electrolytic Refining of Argentiferous Copper," and "Electrolyzing Copper-Nickel Matte."

WATSON, JOHN R., was educated at Bolton High School, Lancashire, at Manchester Technical School and at Normal School of Science, London. For nine years he was employed by Bruner Mond & Co., in England, as engineer, and in 1893-94 he remodeled the plant of the Fords Alkali Co., the bicarbonate plant at Natrona, Pa., and the Diamond soda plant at Milwaukee, Wis. Mr. Watson has been connected with the American Alkali Co., and at present is employed as engineer for the Lake Superior Power Co. He contributes to this volume the paper, "Rotating Cylindrical Furnace for Roasting Sodium Bicarbonate."

WILSON, JOHN KITCHENER, was graduated at the Auckland University College, New Zealand, in 1892, having obtained also at the School of Mines of the New Zealand Government a certificate in assaying and metallurgy. For the next two years he was an assayer and chemist with the Cassel Gold Extracting Co., in New Zealand, and afterwards as cyanide expert he worked for several large companies. Later, in 1898, Mr. Wilson became chief metallurgist at the Golden Horse-Shoe Estates Co., Ltd., of Kalgoorlie, but resigned this position in 1900 for an appointment in South Africa, where, as a member of the Imperial Light Horse, he is at present engaged in active service against the Boers. He is an Associate Member of the Institution of Mining and Metallurgy, London, and a member of the Australian Institute of Mining Engineers. Mr. Wilson contributes to this volume the paper, "The Filter Press Treatment of Slime."

INTRODUCTION.

THE total value at the place of production of the mineral and metal output of the United States in 1900 was $1,365,608,583, as compared with $1,218,214,637 in 1899, a gain of $147,393,946 for the year.

Of these vast sums, which are without precedent in the history of the mineral industry, ores and minerals contributed $672,090,416 in 1900 and $587,268,798 in 1899; metals, $524,432,533 in 1900 and $496,057,320 in 1899; secondary products, $72,720,695 in 1900 and $64,416,979 in 1899; while the value of metals smelted or refined from foreign material was $96,364,939 in 1900 and $70,471,540 in 1899. In these gross totals of value are included certain duplications, such as those of the manganese and iron ore used in making ferromanganese and pig iron; bauxite used in making aluminum and alum; coal used in making coke; lead used in making white and red lead and litharge and a few other duplications, the whole amounting in 1900 to $116,768,662 and in 1899 to $92,581,031. Deducting these amounts and also the values of the crude foreign ores or metals smelted or refined here, the net value of the mineral industry of the United States was $1,152,474,982 in 1900, and $1,055,162,066 in 1899.

In the preparation of the statistics for this volume, the figures previously reported for 1899 have been revised in the light of later and more minute investigation, in accordance with our practice, wherefore it is important for students to observe the caution to use always the figures in the latest volume of THE MINERAL INDUSTRY. There are no statistical reports of this nature which are absolutely correct, owing to the practical impossibility of obtaining accurate reports from all the producers in some extensive and greatly subdivided industries, the absence of records on the part of many producers which prevents them from making returns, the unwillingness of a few to give their figures, and confusion as to the stage in which many products are to be reported. The last difficulty is especially likely to lead to errors in values, some producers estimating the worth of their product at the pit's mouth, and others reporting it in a more or less advanced state of completion, including thus not only the cost of carriage, but also the cost of manipulation. These difficulties appear not only in our own statistics, but also in the statistics reported by various governments. In our own work, however, we make a practice of going backward and correcting figures previously reported, whenever mistakes are discovered by subsequent investigation.

We have made great use of the reports of several State geological surveys,

especially those of Alabama, Kansas, Iowa and Montana, and the State mining bureaus of California and Colorado. We have generally credited these figures to the proper sources in the subsequent pages, but this acknowledgment may stand for any unintentional oversights.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES. (FIRST PRODUCTS.)

Number.	Products.	Customary Measures.	1899. Quantity. Customary Measures.	1899. Quantity. Metric Tons.	1899. Value at Place of Production. a Totals.	1899. Value at Place of Production. a Per M. Ton.	1900. Quantity. Customary Measures.	1900. Quantity. Metric Tons.	1900. Value at Place of Production. a Totals.	1900. Value at Place of Production. a Per M. Ton.
					$	$			$	$
1	Asbestos	Sh. T.	912	827	13,860	16·76	1,100	998	16,500	16·53
2	Asphaltum	Sh. T.	15,060	13,662	308,130	22·55	11,140	10,106	218,520	21·62
3	Asphaltic limestone	Sh. T.	10,378	9,415	54,422	5·78	3,910	3,547	16,830	4·74
4	Bitumin's sandstone	Sh. T.	42,104	38,196	123,229	3·23	34,277	31,096	138,892	4·47
5	Barytes	Sh. T.	32,636	29,607	137,071	4·63	41,466	37,618	161,717	4·30
6	Bauxite	L. T.	36,813	37,402	101,235	2·71	23,445	23,820	85,922	3·61
7	Bismuth ore	Sh. T.	75	68	9,000	132·35	221	200	26,500	132·50
8	Bromine	Lb.	433,003	196	125,571	640·67	521,444	236	140,790	596·57
9	Calcium borate. c	Sh. T.	24,068	21,834	n 505,428	23·15	25,350	22,997	532,350	23·15
10	Cement, nat. hydraul.	g Bbls	9,686,447	1,318,123	5,058,500	3·84	9,177,222	1,248,828	4,308,709	3·45
11	Cement, Portland	h Bbls	5,805,620	1,053,365	10,441,431	9·91	7,991,639	1,449,994	10,461,910	7·21
12	Chrome ore	L. T.	100	102	1,000	9·84	*Nil.*	*Nil.*	*Nil.*	*Nil.*
13	Clay products				74,064,628				78,704,678	
14	Coal, anthracite	Sh. T.	60,622,398	54,996,279	103,753,780	1·89	57,464,235	52,131,212	102,972,596	1·97
15	Coal, bituminous	Sh. T.	191,456,350	173,688,061	172,301,679	0·99	210,821,727	191,256,216	219,460,521	1·15
16	Coal, cannel	Sh. T.	36,639	33,239	91,597	2·76	29,471	26,736	88,413	3·31
17	Cobalt oxide	Lb.	10,200	k 4,627	15,810	k 3·42	12,270	k 5,566	22,085	k 3·97
18	Copper sulphate. f	Lb.	67,903,370	30,801	m 3,530,975	114·64	78,218,478	35,480	m 3,903,102	110·01
19	Corundum	Sh. T.	970	880	78,570	89·28	830	753	58,100	77·16
20	Emery	Sh. T.	3,000	2,722	150,000	55·11	4,200	3,810	189,000	49·06
21	Feldspar	L. T.	26,968	27,399	137,866	5·03	29,447	29,918	136,773	4·57
22	Fluorspar	Sh. T.	24,030	21,800	152,655	7·00	21,656	19,646	114,430	5·82
23	Fullers earth	Sh. T.	13,620	12,356	81,900	6·63	11,813	10,717	70,565	6·58
24	Garnet	Sh. T.	2,565	2,327	72,672	31·23	3,285	2,980	92,801	31·14
25	Grahamite	Sh. T.	3,150	2,858	n 97,650	34·17	3,279	2,975	98,370	33·07
26	Graphite, crystalline	Lb.	3,632,608	k 1,647,740	145,304	k 0·09	4,103,052	k 1,861,132	164,122	k 0·09
27	Graphite, amorphous	Sh. T.	1,030	934	8,240	8·82	1,045	948	8,640	9·11
28	Gypsum	Sh. T.	422,061	382,891	1,155,581	3·02	484,202	439,265	1,316,255	3·00
29	Iron ore	L. T.	25,291,804	25,696,473	58,171,149	2·26	25,917,393	26,332,071	77,752,179	2·95
30	Lepidolite	Sh. T.	124	112	4,600	41·07	100	91	3,700	40·66
31	Magnesite. c	Sh. T.	2,000	1,814	7,600	4·19	2,708	2,456	11,832	4·82
32	Manganese ore. i	L. T.	143,256	145,548	306,476	2·10	218,222	221,714	461,994	2·08
33	Mica, scrap	Sh. T.	6,917	6,275	o 50,956	8·12	5,417	4,914	o 42,889	8·73
34	Mica, sheet	Lb.	97,586	k 44,265	76,926	k 1·74	127,241	k 57,716	82,508	k 1·43
35	Molybdenum ore	Sh. T.	18	16	900	56·25	24	22	1,200	54·55
36	Monazite	Lb.	330,000	150	18,480	123·20	908,000	412	50,680	123·01
37	Natural gas				e 18,000,000				e 18,500,000	
38	Ocher. p	Sh. T.	42,286	n 38,362	n 465,146	12·13	41,917	n 38,027	461,087	12·13
39	Petroleum, crude	g Bbls	57,234,304	8,007,368	64,143,890	8·01	62,538,544	8,749,458	74,246,582	8·48
40	Phosphate rock	L. T.	1,663,476	1,690,092	6,350,144	3·76	1,527,711	1,552,154	5,375,956	3·46
41	Precious stones				175,000				200,000	
42	Pyrites	L. T.	178,408	181,263	583,323	3·22	201,317	204,538	684,478	3·35
43	Salt. q	Bbls.	19,861,948	2,522,610	5,437,941	2·16	20,738,729	2,633,967	6,439,006	2·44
44	Silica, brick	M.	45,000		850,000		49,531		916,819	
45	Diatom. earth	Sh. T.	1,136	1,031	8,216	7·27	1,375	1,247	9,675	7·76
46	Flint	Sh. T.	24,305	22,049	56,481	2·56	35,915	32,582	84,400	2·59
47	Sand, etc	L. T.	e 850,000	863,600	e 1,338,580	1·55	e 875,000	889,000	e 1,312,500	1·48
48	Pumice	Sh. T.	340	308	n 1,700	5·52	250	227	n 1,250	5·51
49	Grindstones	Sh. T.	43,959	39,879	501,985	12·59	42,039	33,138	482,462	12·65
50	Whetstones				115,220				84,874	
51	Tripoli	Sh. T.	2,102	1,907	4,729	2·48	1,846	1,675	3,987	2·38
52	Slate, roofing	Sq'es.	1,098,374	332,146	3,055,988	j 2·78	990,036	299,385	2,885,153	j 2·91
53	Manufactures				540,434				502,051	
54	Pigment	Sh. T.	4,911	4,455	50,338	11·30	6,617	6,003	72,787	12·13
55	Soapstone	Sh. T.	20,011	18,153	189,504	10·44	18,956	17,197	189,560	11·02
56	Soda, natural. r	Sh. T.	10,500	9,526	147,000	15·43	14,100	12,791	195,300	15·27
57	Stone, for building				e 39,600,000				e 41,400,000	
58	Stone, limestone (flux)	L. T.	6,707,435	6,814,754	3,475,525	0·51	6,790,200	6,898,843	3,666,708	0·53
59	Stone, lithographic	Sh. T.	40	36	n 2,000	55·56	40	36	n 2,000	55·56
60	Strontium sulphate	Sh. T.	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
61	Sulphur	L. T.	1,565	1,590	m 33,585	21·12	4,630	m 4,704	102,091	21·70
62	Sulphuric acid. f. l	Sh. T.	59,572	54,043	m 1,328,456	24·59	85,000	77,111	m 2,045,950	26·53
63	Talc, common	Sh. T.	6,671	6,052	51,763	8·55	7,770	7,049	60,217	8·54
64	Talc, fibrous	Sh. T.	57,120	51,819	272,595	5·26	45,000	40,824	236,250	5·79
65	Tungsten ore	L. T.	168	171	33,600	196·49	220	224	35,200	157·14
66	Uranium ore	Sh. T.	43	39	21,500	551·28	153	139	e 45,900	330·22
67	Zinc sulphate	Sh. T.	528	479	n 21,648	45·19	527	478	22,657	47·40
68	Zinc ore, exported	Sh. T.	27,101	24,584	725,944	29·53	42,062	38,156	1,133,663	30·00
69	Zinc white. s	Sh. T.	39,663	35,982	3,331,692	92·04	47,151	42,775	3,772,080	88·18
70	Est. prod. unspecified				5,000,000				5,000,000	
	Totals				587,268,798				672,090,416	

PRODUCTION OF METALS IN THE UNITED STATES.

Number.	Products.	Customary Measures.	1899. Quantity. Customary Measures.	1899. Quantity. Metric Tons.	1899. Value at Place of Production. Totals.	1899. Value at Place of Production. Per M. Ton.	1900. Quantity. Custom'y Measures.	1900. Quantity. Metric Tons.	1900. Value at Place of Production. Totals.	1900. Value at Place of Production. Per M. Ton.
					$	$			$	$
71	Aluminum	Lb.	6,500,000	*k* 2,948,381	*m* 2,112,500	*k* 0·72	7,150,000	*k* 3,243,219	*m* 2,288,000	*k* 0·71
72	Antimony	Lb.	2,500,000	1,137	241,250	212·18	3,200,000	1,452	301,440	207·60
73	Copper	Lb.	581,319,091	263,685	100,916,994	*t* 382·72	600,832,505	272,536	97,755,449	*t* 358·69
74	Ferromanganese*u*	L. T.	219,768	223,284	18,350,628	82·19	255,977	260,073	22,825,469	87·77
75	Ferromolybden'm	Lb.	6,000	2·7	3,000	1,102·30	11,000	5	12,100	2,420·00
76	Gold	Oz(*w*)	3,391,196	*k* 105,471	70,096,021	*k*664·60	3,781,310	*k* 117,611	78,159,674	*k* 664·60
77	Iron, pig	L. T.	13,400,735	13,615,350	234,725,754	17·24	13,533,265	13,749,797	250,184,857	18·49
78	Iridium	Oz(*w*)	5·6		165		8		311	
79	Lead	Sh. T.	217,085	196,938	19,407,399	98·55	275,907	250,301	24,114,272	96·34
80	Molybdenum	Lb.	30,000	*k* 13,608	37,500	*k* 2·76	32,000	*k*14,515	46,080	*k*3·17
81	Nickel	Lb.	22,500	*k* 10,205·6	*m* 8,156	*k* 0·80	9,715	*k*4,407	*m*4,534	*k*1·02
82	Platinum	Oz(*w*)	*Nil.*	*Nil.*	*Nil.*	*Nil.*	173	*k* 5·4	3,114	*k* 576·67
83	Quicksilver (*x*)	Fl'sks	28,879	993	1,155,160	1,163·30	27,855	967	1,288,851	1,332·84
84	Silver	Oz(*w*)	57,126,834	*k* 1,776,829	34,036,168	*k*19·16	59,561,797	*k*1,852,564	36,576,900	*k*19·74
85	Tungsten	Lb.	45,000	*k* 20,412	54,000	*k*2·87	57,000	25,855	51,800	2·00
86	Zinc	Sh. T.	129,675	117,644	14,912,625	126·76	123,231	111,794	10,819,682	96·78
	Totals				$496,057,320				$524,432,533	

SECONDARY MINERAL AND CHEMICAL PRODUCTS OF THE UNITED STATES.

Number.	Products.	Customary Measures.	1899. Quantity. Customary Measures.	1899. Quantity. Metric Tons.	1899. Value at Place of Production. *a* Totals.	1899. Value at Place of Production. *a* Per M. Ton.	1900. Quantity. Custom'y Measures.	1900. Quantity. Metric Tons.	1900. Value at Place of Production. *a* Totals.	1900. Value at Place of Production. *a* Per M. Ton.
					$	$			$	$
87	Alum	Sh. T.	27,276	24,745	845,556	34·17	20,531	18,626	615,930	33·07
88	Aluminum sulphate	Sh. T.	81,805	74,213	2,106,479	28·38	61,678	55,954	1,480,272	26·45
89	Ammonium sulphate	Sh. T.	7,051	6,397	352,539	55·11	(*b*)	(*b*)	(*b*)	(*b*)
90	Carborundum	Lb.	1,741,245	790	156,712	198·37	2,401,000	1,089	216,090	198·43
91	Cement, slag	*h*Bbls	244,757	44,408	360,800	8·10	490,150	88,932	622,490	7·00
92	Coke	Sh. T.	18,079,229	16,401,369	42,148,468	2·57	19,206,994	17,424,471	50,272,050	2·89
93	Copperas	Sh. T.	13,770	12,492	108,508	8·69	12,374	11,226	96,517	8·59
94	Crushed steel	Sh. T.	337	306	47,250	154·41	345	313	48,300	154·31
95	Graphite, artificial	Lb.	405,870	*k* 184,101	32,475	*k* 0·18	860,750	*k* 390,434	68,860	*k* 0·18
96	Lead, white	Sh. T.	103,466	93,864	10,812,197	115·20	96,408	87,468	9,910,742	113·31
97	Lead, red	Sh. T.	10,199	9,252	1,070,895	115·67	10,098	9,161	1,050,192	114·64
98	Lead, orange miner'l	Sh. T.	928	842	139,200	165·32	825	748	100,650	134·56
99	Litharge	Sh. T.	10,020	9,090	103,206	113·53	10,462	9,491	1,067,124	112·44
100	Mineral wool	Sh. T.	7,448	6,757	85,899	12·72	6,002	5,445	60,320	11·08
101	Soda, manufactured	M. T.		387,020	5,925,276	15·31		390,000	7,000,500	17·95
102	Venetian red	Sh. T.	6,575	5,965	121,519	20·37	6,352	5,762	110,658	19·21
	Totals				$64,416,979				$72,720,695	

METALS PRODUCED FROM FOREIGN ORES AND BULLION. (*aa*)

Metals.	Customary Measures.	1899. Quantities. Customary Measures.	1899. Quantities. Kg.	1899. Values.	1900. Quantities. Customary Measures.	1900. Quantities. Kg.	1900. Values.
				$			$
Copper	Pounds	40,659,868	18,443,195	7,058,533	62,484,290	28,342,688	10,166,194
Gold	Troy oz.	1,423,439	44,274	29,422,691	1,948,519	60,605	40,275,883
Lead	Short tons	76,423	69,330,491	6,832,216	103,341	93,750,340	9,032,003
Nickel	Pounds	8,048,343	3,650,708	2,917,525	7,713,120	3,498,648	3,599,713
Silver	Troy oz.	40,542,858	1,261,014	24,240,575	46,619,726	1,450,024	33,291,146
Total values				70,471,540			96,364,939
Total ores and minerals				$587,268,798			$672,086,716
Total metals				496,057,320			524,432,533
Total secondary products				64,416,979			72,720,695
Grand total, values				$1,218,214,637			$1,365,604,883

In using the statistics in the foregoing tables reference should also be made to the detailed tables under the respective captions further on in this volume, where many explanatory notes as to the statistics will be found. The following notes refer to the four preceding tables: (*a*) Except where otherwise specified. (*b*) Not enumerated. (*c*) Amount or value of crude mineral. (*d*) Partly estimated. (*e*) Estimated. (*f*) Includes by-product production. (*g*) Barrels of 300 lb. (*h*) Barrels of 400 lb. (*i*) Includes manganiferous iron ore; this is not duplicated in the report of iron ore. (*j*) Value per square, *i.e.*, 100 sq. ft., lapped and laid; the weights are calculated on the basis 3 squares = 2,000 lb., but these figures are only approximately correct. (*k*)

Kilograms or per kilogram. (*l*) Reduced to a basis of 66° B. (*m*) Average market price at New York. (*n*) Nominal. (*o*) Value before grinding. (*p*) Includes ocher, umber, sienna, and oxide of iron. (*q*) Includes salt used for the manufacture of alkali; the barrel of salt weighs 280 lb. (*r*) Reduced to a basis of 58% ash. (*s*) Includes a small amount made from spelter. (*t*) Average value of Lake copper at New York, less 0·25c. per lb. (*u*) Includes spiegeleisen, though the total value is reckoned as if the whole product were ferromanganese. (*v*) Average market price at Pittsburg. (*w*) Troy oz. (*x*) Flasks of 76·5 lb. (*y*) Barrels of 42 gal. (*z*) Includes a comparatively small amount made directly from ores. (*aa*) Not included in the preceding tables.
Abbreviations: Sh. T., short tons (2,000 lb.); L. T., long tons (2,240 lb.); M. T., metric tons (2,204·6 lb),

METALS AND ALLOYS.

Aluminum.—Production of aluminum in the United States in 1900 was 7,150,000 lb. ($2,288,000) against 6,500,000 lb. ($2,112,500) in 1899. The high price of copper during 1900 was an important factor in increasing the consumption of aluminum.

Antimony.— The production of antimony in the United States in 1900 was 3,200,000 lb. ($301,440) against 2,500,000 lb. ($241,250) in 1899.

Copper.—The production increased from 581,319,091 lb. ($100,916,994) to 600,832,505 lb. ($97,755,449). The main increase was in Montana, Utah and California. Arizona and Lake Superior fell off somewhat.

Ferromanganese.—The production of ferromanganese, including spiegeleisen was 255,977 long tons ($22,825,469) against 219,768 long tons ($18,350,628) in 1899.

Ferromolybdenum.—The production in 1900 was 11,000 lb. ($12,100) against 6,000 lb. ($3,000) in 1899.

Gold and Silver.—The domestic production of gold in 1900 was 3,781,310 troy oz. ($78,159,674) against 3,391,196 troy oz. ($70,096,021) in 1899. The production of silver was 59,561,797 troy oz. ($36,576,900) against 57,126,834 troy oz. ($34,036,168). Colorado's production of gold increased, principally due to Cripple Creek. South Dakota, California and Alaska, including Cape Nome and the American Yukon, also contributed to the increased production. Besides the production reported, 1,948,519 oz. of gold and 46,619,726 oz. of silver were smelted in the United States from imported ores. The average value of silver in the United States in 1900 was 61·41c. per oz. against 59·58c. per oz in 1899.

Iron.—The production of pig iron in 1900, exclusive of ferromanganese and spiegeleisen was 13,533,265 long tons ($250,184,857) against 13,400,735 long tons ($234,725,754) in 1899. Of the production in 1900, 7,943,452 long tons were Bessemer pig against 8,202,778 long tons in 1899. Basic pig increased from 985,033 to 1,072,376 long tons. The remainder of the output is classed as foundry and forge iron.

Lead.—The domestic production in 1900 was 275,907 short tons ($24,114,272) against 217,085 short tons ($19,407,399) in 1899. The great increase was due largely to the activity in the Idaho mines. The average price of lead at New York was 4·37c., against 4·47c. per lb. in 1899. Besides the above, the American smelters in 1900 recovered 103,341 tons of lead from foreign ore and base bullion, against 76,423 tons in 1899.

Molybdenum.—Some 32,000 lb. of molybdenum ($46,080) were produced in 1900, against 30,000 lb. ($37,500) in 1899. A considerable portion of the ore came from Arizona.

Nickel.—The domestic production of nickel was 9,715 lb. ($4,534) against 22,500 lb. ($8,156) in 1899.

Platinum.—There was a production of 173 troy oz. ($3,114) of platinum from domestic ores in 1900, but no metal was recovered in the previous year. The value of bar platinum at New York in 1900 ranged from $17·75 to $18·20 per oz.

Quicksilver.—The production of quicksilver decreased to 27,855 flasks ($1,288,851) from 28,879 flasks ($1,155,160) in 1899, notwithstanding the high prices and the reopening of many old mines. Texas contributed 1,700 flasks to the total.

Tungsten.—The production was 57,000 lb. ($51,800) in 1900, against 45,000 lb. ($54,000) in 1899. The exact statistics have not been available for the production of ferrotungsten.

Zinc.—The production in 1900 was 123,231 short tons ($10,819,682) against 129,675 short tons ($14,912,625) in 1899. Missouri and Kansas increased their production. The average price of spelter in New York in 1900 decreased to 4·39c. per lb. against 5·75c. per lb. in 1899.

Ores, Minerals and Chemical Products.

Alum and Aluminum Sulphate.—The production of crystallized alum in the United States in 1900 was 20,531 short tons ($615,930) against 27,276 ($845,556) in 1899. The production of aluminum sulphate in 1900 was 61,678 short tons ($1,480,272) against 81,805 ($2,106,479) in 1899.

Ammonium Sulphate.—Statistics for the amount of ammonium sulphate recovered by coke works in 1900 are not available at the time of publication, but the production in 1899 was 7,051 short tons. A larger amount of this substance is obtained from the ammoniacal liquor of illuminating gas works, but there are no statistics as to that production. The value of sulphate, basis 25%, was $57·12 per short ton at New York in 1900, against $58·70 in 1899.

Asbestos.—The domestic production was 1,100 short tons ($16,500) in 1900, against 912 short tons ($13,860) in 1899. In each year the production was made almost entirely by one mine in Georgia.

Asphaltum and Asphaltum Products.—The production of asphaltum, liquid and solid, in 1900 was 11,140 short tons ($218,520), against 15,060 ($308,130) in 1899, the output coming from California and Indian Territory. California and Kentucky, chiefly the former, produced 34,277 short tons ($138,892) of bituminous rock in 1900, against 42,104 ($123,229) in 1899. Utah and the Indian Territory produced 3,910 short tons ($16,830) of asphaltic limestone, against 10,378 ($54,422) in 1899. The output of Utah increased in 1900, while that of the Indian Territory showed a large decrease. The production of grahamite or gilsonite in 1900 was 3,279 short tons, against 3,150 in 1899.

Barytes.—The production in 1900 was 41,466 short tons ($161,717) against 32,636 ($137,071) in 1899. Of the production in 1900 Missouri furnished 16,561 tons, the remainder being obtained in Virginia, North Carolina and Tennessee.

Bauxite.—The production in 1900 was 23,445 long tons ($85,922) against 36,813 ($101,235) in 1899. Of the production in 1899 Georgia furnished 20,715 tons, the remainder being mined in Alabama and Arkansas.

Bromine.—The production in 1900 was 521,444 lb. ($140,790), against 433,003 ($125,571) in 1899. These figures include the bromine equivalent of potassium bromide which is produced in Michigan.

Calcium Borate.—The production in 1900 was 25,350 short tons, against 24,068 in 1899. Most of this product is colemanite, mined in California.

Carborundum.—The production reported by the sole producer was 2,401,000 lb. ($216,090) in 1900, against 1,741,245 lb. ($156,712) in 1899.

Cement.—The total production of Portland cement in 1900 was 7,991,639 bbl. of 400 lb., valued at $10,461,910, against 5,805,620 ($10,441,431) in 1899. The Lehigh district of Pennsylvania and New Jersey has maintained its supremacy as a center of production, and Michigan, and other States also showed important gains. Aside from the remarkable increase in production, the year 1900 was notable for the low prices at which cement was sold in the Eastern markets. The production of natural rock cement in 1900 was 9,177,222 bbl. of 300 lb., valued at $4,308,709, against 9,686,447 ($5,058,500) in 1899. The Kentucky-Indiana district increased its output, but other parts of the United States showed a falling off owing to the competition with Portland cement. The production of slag cement in 1900 was 490,150 bbl. of 400 lb., valued at $216,090, against 244,757 ($360,800) in 1899.

Chrome Ore.—There was no production in 1900, against 100 long tons ($1,000) in the previous year. Chrome mining in California ceased in 1898.

Clay.—The value of brick and other clay products made in the United States in 1900 was $78,704,678, against 74,064,628 in the previous year.

Coal and Coke.—The total production of coal in the United States in 1900 was 268,315,433 short tons ($322,521,530) against 252,115,387 ($276,147,056) in 1899. The production of anthracite, all of it from Pennsylvania with the exception of an insignificant amount from Colorado, was 57,464,235 short tons ($102,972,596) in 1900, against 60,622,398 ($103,753,780) in 1899. Kentucky produced 29,471 short tons ($88,413) of cannel coal against 36,639 ($91,597) in 1899. The remainder of the output each year was bituminous coal, of which Pennsylvania and the Central States are the largest producers, their relative rank in 1900 having been Pennsylvania, Illinois, West Virginia and Ohio in the order named. There was an increase in the output of all of the important coal-producing States in 1900. The total production of coke in 1900 was 19,206,994 short tons ($50,272,050) against 18,079,229 ($42,148,468) in 1899. Pennsylvania furnished about two-thirds of the output each year.

Coal Tar.—No statistics were compiled of the production of coal tar by by-product coke oven plants in 1899 or 1900. In 1898 they turned out 16,021 short tons and 13,304 in 1897. There are no statistics as to the large production of this substance by illuminating gas works.

Cobalt Oxide.—The production of cobalt oxide in 1900 was 12,270 lb., against 10,200 in 1898. The value was $1·80 per lb. in 1900, against $1·55 in 1899.

Copperas.—The production in 1900 was 12,374 short tons ($96,517) against 13,770 (108,508) in 1899. The chief producer in this country is the American Steel & Wire Co., which controls all the wire and rod mills recovering

copperas as a by-product. The above statistics do not include copperas converted into Venetian and Indian reds at the works of original production.

Copper Sulphate.—The production in 1900 was 78,218,478 lb., against 67,903,370 in 1899. Of this the amount recovered as a by-product, chiefly by gold and silver refiners, was 44,368,478 lb. in 1900 and 37,285,870 in 1899. The remainder of the output each year was made from metallic copper previously reported in the production of that metal. The average value of copper sulphate at New York per 100 lb. was $4·99 in 1900, against $5·20 in 1899.

Corundum and Emery.—The production of corundum in 1900, all of it from North Carolina and Georgia, was 830 short tons ($58,100) against 970 ($78,570) in 1899. The production of emery, most of it from Massachusetts, was 4,200 short tons ($189,000) against 3,000 ($150,000) in 1899. The production of steel emery or crushed steel in 1900 was 690,000 lb. ($48,300) against 674,000 ($47,250) in 1899, the entire make each year being supplied by the Pittsburg Crushed Steel Co.

Feldspar.—The production in 1900 was 29,447 long tons ($136,773) against 26,968 ($137,866) in 1899. Pennsylvania, Massachusetts and New York being the chief producers each year.

Fluorspar.—The production in 1900 was 21,656 short tons ($114,430) against 24,003 ($152,655) in 1899, Illinois and Kentucky furnishing the entire output.

Fullers Earth.—The output in 1900 was 11,813 short tons ($70,565) against 13,626 ($81,900) in 1899. The most part each year was mined in the yicinity of Quincy, Fla.

Garnet.—The production in 1900 was 3,285 short tons ($92,801) against 2,565 ($72,672) in 1899, the output each year being furnished by New York, Pennsylvania and Connecticut. The domestic resources of this mineral are large, but the demand for it is limited.

Graphite.—The production of crystalline graphite in 1900 was 4,103,052 lb. ($164,122) as against 3,632,608 lb. ($145,304) in 1899. The production of amorphous graphite in 1900 was 1,045 short tons ($8,640) as against 1,030 tons ($8,240) in 1899. The larger part of the crystalline product in 1900 was obtained from Ticonderoga, N. Y., but a considerable quanity was mined in Pennsylvania, where some of the old mines were reopened. One company produced 860,750 lb. ($68,860) of artificial graphite as against 405,870 lb. ($32,475) in 1899.

Gypsum.—The production increased from 422,061 in 1899 to 484,202 short tons in 1900. These figures represent the amount of crude rock quarried. The more part of the production is marketed as stucco or plaster of Paris.

Iron Ore.—The production in 1900 was 25,917,393 long tons as against 25,291,804 in 1899, these figures being exclusive of the production of manganiferous iron ore, reported separately under manganese. The increase in the production was due chiefly to the Lake Superior ranges, the Southern States showing only a comparatively small gain.

Lead White, Red Lead and Litharge.—The production of white lead in 1900 was 96,408 short tons ($9,910,742) as against 103,466 short tons ($10,812,197) in 1899; of red lead, 10,098 ($1,050,192) as against 10,199 ($1,070,895);

of litharge 10,462 ($1,067,124) as against 10,020 ($103,206); of orange mineral 825 ($100,650) as against 928 ($139,200) in 1899. The most part of these products is obtained by the corrosion of pig lead, but a small part of the white lead product is made directly from ores.

Limestone for Iron Flux.—Iron smelters consumed 6,790,200 long tons in 1900 as against 6,707,435 tons in 1899, the increase being caused by the greater production of pig iron.

Lithographic Stone.—Utah produced 40 short tons in 1900, a like amount in 1899. There was no output previous to 1898, in which year 112 tons were produced.

Magnesite.—In 1900 California produced 2,708 short tons ($11,832) as against 2,000 tons ($7,600) in 1899.

Manganese Ore.—The production of manganese ore, including maganiferous iron ore, was 218,222 long tons, as against 143,256 long tons in 1899. Included in these figures are 75,360 tons of manganiferous iron ore from Michigan and Wisconsin in 1900, as against 53,702 in 1899, and 91,748 tons of franklinite residuum from New Jersey in 1900, against 53,921 in 1899.

Mica.—The production of sheet mica in 1900 was 127,241 lb. ($82,508) against 97,586 ($76,926) in 1898. The production of scrap mica was 5,417 short tons ($42,889) against 6,917 ($50,956), the values of scrap mica being reckoned for the product before grinding. Practically the entire production of mica is made in South Dakota, New Hampshire, North Carolina and Nevada.

Mineral Wool.—The production in 1900 was 6,002 short tons ($60,320) as against 7,448 short tons ($85,899) in 1899. A part of this product was made from slag and a part by the fusion of natural rock, the latter being the more valuable.

Molybdenum Ore.—This ore was produced in the United States in 1900 to the amount of 24 short tons, valued nominally at $50 per ton, against 18 short tons valued at $50 per ton in 1899.

Monazite.—North Carolina produced 908,000 lb. ($50,680) in 1900 as against 330,000 lb. ($18,480) in 1899.

Natural Gos.—The production of natural gas in 1900 is estimated at a value of $18,500,000 as against $18,000,000 in 1899.

Ocher and Oxide of Iron Pigments.—The production of ocher, amber, sienna and natural oxide of iron ground pigment, the last being known commonly as "metallic paint," was 41,917 short tons ($461,087) in 1900 as against 42,286 short tons ($465,146) in 1899. The values are reckoned nominally at $11 per ton each year. These products merge into one another so that no satisfactory division of the statistics is possible. Pennsylvania is the largest producer.

Petroleum.—The total output in 1900 was 62,538,544 bbl. ($74,246,582) as against 57,234,304 bbl. ($64,143,890) in 1899. The increase was due to the Appalachian and the Lima fields. California and Texas made increased outputs as well, while Colorado and Kansas showed a decrease. The above values are calculated for crude oil at the wells. The average value was considerably higher in 1900 than in the previous year.

Phosphate Rock.—The production in 1900 was 1,527,711 long tons ($5,375,-

956) as against 1,663,476 tons ($6,350,144) in 1899. The decrease in 1900 was due to a falling off in the export demand. The prices were much lower, particularly in the latter part of the year.

Salt.—The domestic output of salt increased from 19,861,948 bbl. in 1899, to 20,738,729 bbl. in 1900. Kansas, Michigan and New York each contributed largely to the increase.

Silica.—The production of vein and dike quartz in 1900 was 35,915 short tons as against 24,305 tons ($56,481) in 1899. This material was used chiefly in pottery, for packing acid towers, and for grinding for various purposes. The production of grindstones, which are made out of quartzite, or a very hard sandstone, in 1900, amounted to 42,039 short tons ($482,462) as against 43,959 tons ($501,985) in 1899. These were produced entirely in Ohio and Michigan. The production of oilstones, scythestones and whetstones in 1900 was valued at $84,874 as compared with $115,220 in 1899. Utah produced 250 short tons of pumice stone, valued nominally at $1,250, against 340 ($1,700) in 1899. There was a production of 1,846 short tons of tripoli, valued at $3,987, against 2,102 ($4,729) in 1899, most of this product being obtained in Missouri. The production of diatomaceous earth in the United States in 1900 was 1,375 short tons ($9,675) as against 1,136 tons ($8,216) in 1899.

Slate.—The production of roofing slate in 1900 was 990,036 squares ($2,885,153) as against 1,098,374 squares ($3,055,988) in 1899. The production of slate manufactures, chiefly blackboards and structural material, was valued at $502,051 in 1900 as against $540,434 in 1899. The production of slate pigment, including Baraga graphite and various kinds of mineral black, was 6,617 short tons as against 4,911 short tons in the previous year, the values of the products after grinding being respectively $72,787 and $70,671.

Soda.—The production of soda and soda products from salt, reduced to a common basis of 58% soda ash, was 390,000 metric tons in 1900 as against 387,020 tons in 1899. The average value of 58% ash at the works was $17·95 per metric ton as compared with $15·31 in 1899. California and Nevada produced 14,100 short tons ($195,300) of natural soda, basis 58%, in 1900, against 10,500 short tons ($147,000) in 1899.

Strontium Sulphate.—There was no production of strontium sulphate in 1900 or in 1899, against 2 tons produced in Ohio for experimental purposes in 1898.

Sulphur and Pyrites.—Louisiana, Nevada and Utah produced 4,630 long tons of sulphur in 1900 against 1,565 in 1899. The average price of Sicilian seconds at New York in 1900 was $22·05 per ton, against $21·46 in the previous year. The domestic production of pyrites in 1900 was 201,317 long tons ($684,478) as against 178,408 tons ($583,323) in 1899. Virginia was the largest producer each year, Massachusetts ranking second. Sulphuric acid was recovered as a by-product in roasting blende and pyrites, chiefly the former, to the extent of 85,000 short tons as against 59,572 tons in 1899, the figures being reduced to a common basis of 66° B. Concentrated acid of the latter strength averaged $24·07 per 2,000 lb. at New York in 1900 as against $22·25 in 1899.

Talc and Soapstone.—The production of soapstone for slabs and other manufactured articles in 1900 was 18,956 short tons ($189,560) as against 20,011

short tons ($189,504) in 1899. The production of common talc, mostly ground to powder, was 7,770 short tons (60,217), against 6,671 ($51,763) in 1899. This was produced chiefly in North Carolina, Pennsylvania and Vermont. The production of fibrous talc, all of it from St. Lawrence County, N. Y., was 45,000 short tons ($236,250), against 57,120 ($272,595) in 1899.

Tungsten Ore.—There was a production in 1900 of 220 long tons of tungsten ore from South Dakota, Colorado and Arizona, with small amount from Connecticut and New Mexico, which was valued nominally at $35,200 at the mines. The statistics for 1899 were approximately 168 long tons, valued at $33,600.

Uranium Ore.—In 1900 Colorado produced 153 short tons of uranium ore, estimated at a value of $45,900, as against 43 tons, valued at $21,500 in 1899.

Venetian Red.—The production of Venetian and Indian reds in 1900 was 6,352 short tons ($110,658), against 6,575 ($121,519) in 1899. These figures include only the output at works where the original copperas was made, and do not include any that may have been made by second hands.

Zinc Ore.—The amount of zinc ore of domestic origin exported from the United States in 1900 was 42,062 short tons ($1,133,663) as compared with 27,101 short tons ($725,944) in 1899. Most of the ore exported was mined in New Jersey, although a considerable portion was shipped from Colorado via New Orleans and Galveston.

Zinc Sulphate.—There was a production in 1900, by one concern, of 527 short tons as against 528 in 1899.

Zinc White.—The production in 1900 was 47,151 short tons, against 39,663 in 1899. The total value was $3,772,080 as compared with $3,331,692 in 1899. Nearly all the American production of zinc white is made directly from ores, most of which are mined in New Jersey.

ALUM AND ALUMINUM.

UNDER this general caption are grouped aluminum, alum, bauxite, cryolite, corundum and emery, substances which, previous to Volume VII., appeared under individual captions. The present arrangement is a logical one, since both bauxite and cryolite are used as raw material in the manufacture of aluminum and alum, two industries so interwoven that a logical separation is impossible, and, since corundum, though employed mainly as an abrasive, is now used in part as a source of aluminum. In this view aluminum, alum and the aluminum minerals—bauxite and cryolite, corundum and emery—bear the same relation to one another as do copper, copper sulphate or bluestone and copper ores.

I. BAUXITE.

The production of bauxite in 1900 was 23,445 long tons, valued at $85,922, being a large falling off from the figures of the preceding year. Of the output in 1900, 2,080 tons came from Arkansas and the remainder from the Alabama and Georgia districts. At the beginning of the year the following firms were in operation: Dixie Bauxite Co., Barnsley, Ga.; Georgia Bauxite & Mining Co., Linwood, Ga.; Illinois Chemical Co., Arkansas; Republic Mining & Milling Co., Rock Run, Ala.; Pittsburg Reduction Co., Arkansas; Southern Bauxite Co., Cave Springs, Ga.; and E. Willis, Rome, Ga. The mines of the Illinois Chemical Co. were worked for a part of the year only, shipments commencing in June.

PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION OF BAUXITE IN THE UNITED STATES.

Year.	Production.					Imports.		Exports.		Consumption.	
	Alabama.	Georgia.	Total. (a)								
	Lg. Tons.	Lg. Tons.	Lg. Tons.	Value.	Per Ton.	Lg. Tons	Value.	Lg. Tons.	Value.	Lg. Tons	Value.
1896..	9,796	7,300	17,096	$42,740	$2·50	2,119	$10,477			19,215	$53,217
1897..	13,083	7,507	20,590	51,475	2·50	2,645	10,515	2,537	$5,074	20,708	56,916
1898..	13,848	12,943	26,791	66,978	2·50	1,201	4,238	1,000	2,000	26,992	69,216
1899..	14,144	19,619	36,813	101,235	2·75	6,666	23,768	2,030	4,567	41,449	120,436
1900..	650	20,715	23,445	85,922	3·66	8,656	32,967	1,000	3,000	31,101	115,889

(a) Arkansas produced 3,050 long tons in 1899 and 2,080 long tons in 1900, which are included in the totals for those years.

Alabama and Georgia.—The companies now operating in these States for bauxite, *viz.*, The Republic Mining and Manufacturing Co. and the Southern

Bauxite Co., are nearing the end of their production, as they have less than 20,000 tons in sight at all their mines. Outside of their properties there are about 2,000,000 tons of bauxite available, which are owned and controlled by the Dixie Bauxite Co., of Rome, Ga., and Col. B. F. A. Saylor, of Rome, neither of which are operating. There are about 75 deposits or occurrences of bauxite great and small in Alabama and Georgia in four groups, *viz.*, Dyke district in Cherokee County, Ala., the Bobo district in Floyd and Polk counties, Ga., the Hermitage district in Floyd and Bartow counties, Ga., and the Summerville district in Walker County, Ga. This territory is about 50 miles long by 15 miles wide. A movement is now on foot looking to a consolidation of these interests. These deposits have been fully described in previous volumes of THE MINERAL INDUSTRY, to which reference should be made. The white ore now brings $5·50 per long ton f. o. b. at nearest railroad point and the red ore $5; the freight rates to the Northern chemists who manufacture alum and alumina in Chicago, Pittsburg, Cleveland and Philadelphia and elsewhere average $4·30 per long ton, making it cost them $9·80 and $9·30 per long ton. They sell the alumina largely to the Pittsburg Reduction Co.

Arkansas.—The Pittsburg Reduction Co. did a considerable amount of development work on its bauxite deposits and shipped during 1900 about 1,700 tons to its works at New Kensington, Pa. The quality was said to be good though high in iron; the ore was low in silica, resembling the French bauxites. Mining is cheap in the locality as the deposits are on the surface. The question of marketing, however, is somewhat problematical, as the railways have not as yet made freight rates which will permit of serious competition with the product from Georgia and Alabama.

Imports and Exports.—During 1900 there was an unusually large amount of French bauxite imported at a low price, the statistics for the year being 8,656 long tons, valued at $32,967. The exports for the same period were 1,000 long tons, valued at 3,000.

A discovery of a rather impure bauxite was made near Wilgello, Camden County, New South Wales, in 1899. It occurs as cemented concretionary globules resembling pisolitic brown iron ore. Analyses showed generally high percentage of ferric oxide, though a picked sample showed H_2O (total); 32·68%; Fe_2O_3, 2·85%; TiO, 2·4%; Al_2O_3, 58·31%; SiO_2, 1·80%; P_2O_5, 0·66%. The general average would seem to be about H_2O (combined and uncombined) 22·30%; Fe_2O_3, 20·34%; Al_2O_3, 39·82%; TiO_2, 5·50%; SiO_2, 10·30%; P_2O_5, 0·56%.

PRODUCTION OF BAUXITE IN THE PRINCIPAL COUNTRIES. (IN METRIC TONS.)

Country.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
France	33,923	26,032	17,958	33,820	41,740	36,723	48,215
United Kingdom	8,880	8,097	10,574	7,365	13,449	12,600	8,137
United States	11,204	10,904	19,101	17,370	20,919	27,220	37,402
Total	54,007	45,033	47,633	58,555	76,108	76,543	93,754

II. Corundum and Emery.

The new occurrences of corundum at the Sheffield mine, Macon County, N. C., and at the top of the Blue Ridge Mountains extending from Clay County, N. C., to Rabun County, Ga., have been described by J. H. Pratt in the *American Journal of Science,* October, 1900. In the Sheffield mine the corundum occurs in seams a few feet wide at intervals in the rocks and while it may constitute 10% of these veins the amount in the rock that it would be necessary to mine would probably be between 3 and 4%. The occurrence of corundum in amphibole schist and the general character and shape indicate that it was an original constituent of the igneous rock and not formed during metamorphism. The Blue Ridge deposit is in quartz schists which have a general strike N.E. to S.W. with a dip of 30° N.W. A portion of these schists contain from 2 to 5% corundum.

PRODUCTION OF CORUNDUM AND EMERY IN THE UNITED STATES. (*a*)

Substance.	1897.			1898.			1899.			1900.		
	Tons. (*b*)	Value.	Per Ton.	Tons. (*b*)	Value.	Per Ton.	Tons. (*b*)	Value.	Per Ton.	Tons. (*b*)	Value.	Per Ton.
Corundum	293	$19,810	$67·61	786	$63,630	$80·96	970	$78,570	$81·00	830	$58,100	$70·00
Emery	1,900	*c* 92,000	48·42	2,956	*c* 143,800	48·65	3,000	150,000	50·00	4,200	189,000	45·00
Steel emery	324	51,824	159·95	330	46,200	140·00	337	47,250	140·21	345	48,300	140·00
Total	2,517	$163,634		4,072	$253,630		4,237	$275,820		5,375	$295,400	

(*a*) The values are based on the prices at the mines, but except in the case of steel emery are of slight significance owing to the great range between the different grades of the minerals. The changes in the annual averages do not indicate fluctuations in market quotations so much as changes in the proportion of different grades of mineral in the total. (*b*) 2,000 lb. (*c*) More or less nominal.

IMPORTS OF EMERY INTO THE UNITED STATES.

Year.	Grains.		Ore or Rock.		Other M'f'es.	Total Value.	Year.	Grains.		Ore or Rock.		Other M'f'es.	Total Value.
	Pounds	Value.	Long Tons.	Value.	Value.			Pounds	Value.	Long Tons.	Value.	Value.	
1893..	516,953	$20,073	5,066	103,875	$3,819	$127,767	1897..	520,095	$20,022	5,209	$107,649	$2,211	$129,882
1894..	597,713	18,645	2,804	51,487	1,847	71,973	1898.	577,655	23,320	5,547	106,269	3,810	133,399
1895..	678,761	25,066	6,803	80,386	27,586	133,038	1899.	728,299	29,124	7,435	116,493	11,514	157,131
1896..	751,464	26,520	6,289	119,667	1,971	148,158	1900.	661,482	26,520	11,392	202,980	10,006	239,506

The International Emery & Corundum Co., with a capital of $2,000,000, in common stock, has been incorporated under New Jersey laws and has absorbed the Hampden Emery & Corundum Co., with works at Chester, Mass., emery mines in Massachusetts and corundum mines in Georgia and North Carolina. The new company has also made contracts for the output of the Turkish mines for the United States.

Emery occurs near Whittles, in Pittsylvania County, Va., though the quality is hardly good enough to give it any value as an abrasive. The rational analysis corresponds to 22·48% magnetite, 33·34% hercynite and 33·16% corundum. The iron occurs in it largely in the ferrous state while in the emery of Chester, Mass., it is present entirely as a magnetite with the alumina as corundum, which

readily accounts for the difference in abrasive power of the material from the two localities.

During the year 1900 a reorganization of the Canada Corundum Co., of Toronto, Canada, has been effected under the slightly modified title of the Canada Corundum Co., Ltd., with American office at Bridgeport, Conn. This company is the only one that has carried on any extensive operations during 1900, although in the fall a Boston company commenced exploratory work on the Armstrong prospect which was continued into the winter and will probably be actively resumed in the spring. The operations of the Canada Corundum Co., Ltd., are confined to the Robillard mine in Raglan township. Their property is 7 miles south of Combermere and 20 miles from the Canada Atlantic Railway. Work was commenced here April 1, 1900, and a small experimental plant was erected to demonstrate the practicability of concentrating and washing the rock, especially with a view to determine the scheme to be followed in designing a large plant. The equipment consisted of a No. 2 Gates crusher, one set of 14×24 in. Gates rolls, two Hartz 2-compartment jigs, a Wilfley and a Bartlett concentrating table, with the necessary elevators, trommels, etc. The water power was developed by the installation of a Leffel "37X" Cascade wheel under a head of 46 ft. and the power was transmitted 315 ft. by a 0·625 in. wire rope. About 50 tons of concentrates were produced during the latter part of the summer, which demonstrated that the mineral could be concentrated satisfactorily, but the finishing up or washing had not been made. The mill was then shut down and a larger plant was installed, where operations were resumed in February, 1901. The concentrates on hand were rewashed and some corundum shipped. The removal of the last 15% of feldspar presents the greatest difficulty and necessitates the sacrifice of a certain percentage of corundum to bring the finished product up to the required 90% purity. In general appearance the Canadian corundum shows more cleavage and is duller in luster than that of the Southern States. The grain, however, is fairly strong and the cutting edges are sharp. This angularity or flatness of the grain and lack of luster is largely due to the difference in the method of treatment in the two sections, though the Canadian corundum shows more cleavage than the crystals from the South.

The mill rock is quarried from the south side of the Robillard Hill in the lower of two parallel belts of corundum-bearing rock which traverse the hill from east to west or nearly so. The belt is about 300 ft. wide and lies in such a position along the face of the hill that it can be quarried and loaded into wagons or cars with the utmost economy. There are large bodies of richer ore at intervals along the belt, together with stretches of barren material which is readily and cheaply disposed of down the side of the hill. The company contemplates the erection of a 300-ton mill as soon as the experimental plant has served its time and purpose. Transportation is made by wagon to a point on the York River, 3·5 miles distant, from whence during the summer months it is shipped by boat 16 miles to Barry's Bay, a station on the Canada Atlantic Railway. During the winter the shipments are made 21 miles via Combermere direct to the railway

by team. It is quite probable that the coming summer will see considerable prospecting in this territory.

EMERY.—*Greece.*—Through the efforts of the International Control Committee the Government has established a depot for Naxos emery at Syra and the difficulties are now avoided which were formerly experienced by shippers either in dealing with the native emery laborers or in the danger incurred by loading vessels at Liona and Montzouna Bays, which are unprotected in rough weather. The stocks will be maintained up to 5,000 tons of well selected mineral. The price of emery delivered at the depot is 106·5 fr. per metric ton, including the Government tax of 7·9 drachmas per ton. Some 500 tons have recently been sold at the depot for exportation to Boston. In certain European ports the Naxos emery has frequently been found admixed with the Asia Minor product. The value of the latter being only one-third that of the Naxos, for obvious reasons vessels carrying it call at Naxos on their way to complete the cargo taken at Smyrna. To avoid any possible disappointment that might arise through this complication, it is advisable for manufacturers to insist on a consular certificate of origin with every consignment. In 1899 a total of 5,139 tons, valued at $109,240, was consigned to buyers for exportation and about 276 tons to the lessees of the emery stores recently established at Syra, where the price, 106·50 fr. per metric ton, is the same as at Naxos. The consignment of emery at the ports of Liona and Montzouna is henceforth prohibited. The establishment of the emery depot at Syra mentioned above shows that the Government has seen the necessity for prompt action in order to restore Greek emery to its former reputation. Modern mining is now carried on under the supervision of expert engineers and the small pieces of emery which were formerly rejected with the rubbish, are now salable at a low rate. The inferior mineral at Taros and Sikinos will be mined and classed as second and third qualities, respectively. These products will compete favorably with the Asia Minor emery. The Naxos output is controlled by the Greco-Turkish Emery Stone Co., recently incorporated under the laws of New Jersey, at a capitalization of $300,000.

THE EMERY DEPOSITS OF WESTCHESTER COUNTY, NEW YORK.*

BY EDWIN C. ECKEL.

THE emery deposits of Westchester County, N. Y., are located south and southeast of Peekskill, within a radius of 5 miles from that village. The sedimentary rocks in this part of the county consist of four formations, which, beginning with the lowest are: 1. Algonkian (Fordham gneiss). 2. Cambrian (Lowerre quartzite). 3. Silurian (Inwood crystalline limestone). 4. Silurian (Manhattan mica-schist).

These sediments have been highly metamorphosed, and folded so as to give steep dips, usually not less than 40°. South of Peekskill, the limestone and mica-schist have been further altered by the intrusion of a large mass of very basic igneous rocks. The main body of this intrusion, covering an area of about

* This paper is based on data collected for the New York State Museum.

6 miles from east to west, and 4 miles from north to south, consists of peridotites, norites, and diorites, and contains the emery deposits.

The magnetic iron ores of this vicinity early attracted attention, and for some time furnished a certain quantity of ore to nearby furnaces, which was, however, very difficult to reduce in the furnaces, and its use was finally abandoned on that account. In 1874* Dr. James P. Kimball called attention to the high alumina content of these ores, and suggested their use in the blast furnace with magnesian or silicious iron ores, reiterating his arguments in 1881.† The ores were never thus used, and at present are mined as emery only. Upon the discovery that the former iron ores possessed valuable abrasive qualities, an emery mill was erected at Peekskill, with the expectation of working on this domestic material, but Naxos ore was finally substituted.

Structurally, the emery deposits occur as a series of vein-like bodies, of considerable constancy longitudinally, but fading out into the wall rock (norite) laterally. This lateral transition appears to be generally effected through a biotite-emery rock (which is mined so long as the proportion of emery is sufficiently high), passing into a mica norite, and finally into the normal norite. Though their mineral character and the fading into wall rock at the sides make it highly probable that the ore-bodies are merely highly basic segregations in the magma, the possibility still remains that they may be the results of metamorphic action upon pre-existing materials.

The emery itself varies from steel-blue color to steel-gray or almost black, containing in places bluish white crystals 0·25 to 0·5 in. in length. Mr. H. P. Whitlock states that sections from the ordinary grade show the corundum to be associated with hercynite, magnetite, aggregates of quartz, feldspar, hornblende and biotite; while the best grade shows large lathlike phenocrysts of corundum, somewhat altered along the cleavage cracks, and imbedded in a ground mass of hercynite. Analysis No. 13 has been added, to show the composition of the normal norite of the region.

ANALYSIS OF PEEKSKILL EMERY ORES.

Constituents.	Reported by Prof. Geo. H. Williams.							Reported by Dr. J. P. Kimball.					Reported by Prof. J. F. Kemp.
	1	2	3	4	5	6	7	8	9	10	11	12	13
	%	%	%	%	%	%	%	%	%	%	%	%	%
Al_2O_3	31·93	40·77	37·78	37·43	36·49	41·66	46·53	39·36	41·28	44·58	36·46	34·47	17·79
FeO								45·86	undet	21·14	18·49	17·92	6·03
Fe_2O_3	18·19	18·37	24·35	21·17	21·36	23·71	32·31			25·86	28·21	28·70	2·08
MgO	7·41	6·73	7·92	7·20	8·39	7·91	9·43	7·18					5·85
Fe_3O_4	34·20	32·01	17·37	19·81	22·77	14·76	8·98						
TiO_2	1·12	1·08	0·62	0·65	0·67	0·54	0·51	2·41	3·90	3·88	3·52	4·41	
S	0·04	0·04	0·02	0·02	0·02	0·01	0·01						
P_2O_5	Trace	Trace	Trace	Trace	Trace	Trace	Trace	0·22	undet	0·16	0·09	0·16	
FeS_2								2·63					
CaO								0·47					6·84
SiO_2								0·51	0·32	1·13	1·04	2·88	54·72
Na_2O													3·02
K_2O													3·01

Analyses 1 to 12 were made on ore from different points in the area. It is

* *Journal of the Society of American Chemists*, IV., p. 321.

† *Transactions of the American Institute of Mining Engineers*, IX., p. 13.

not now possible to identify all the openings which were sampled, but the analyses will represent very closely the composition of the ores now mined as emery.

At present two companies are engaged in exploiting this field. The Jackson Mills Emery Co., of Easton, Pa., has secured the mineral rights on the land owned by Isaac McCoy, 3 miles east of Peekskill, where it mines on a combined lease and royalty system. The emery on this tract occurs on a north and south trending ridge, about a mile long and half a mile wide; and almost every acre of the surface shows traces of excavations made in search of emery. The principal opening, and the only one in the entire emery region large enough to be called a mine, is located near the highest point of the ridge. The ore here takes the form of an almost vertical vein, with several small branches. A tunnel was formerly run on the vein, but it caved, and at present the deposit is worked as an open cut. The vein is followed as closely as possible, both wall rocks being left in position. As the difference in appearance between the emery and the norite is not particularly marked, a representative of the company supervises the operations.

The rock is blasted with comparatively light charges, sledged to convenient size and roughly graded by eye. During 1900 the workings cut into a portion of the deposit which contains visible crystals of corundum 0·25 to 0·5 in. in length, and this high grade material is shipped separately. Before this find, only one grade was handled, which was cobbed roughly, to remove the non-productive rock as much as possible. The product is carted to Peekskill, and shipped to Easton, Pa.

The Tanite Co., of Stroudsburg, Pa., controls most of the properties, aside from those on the McCoy farm, and ships a considerable quantity yearly to its works. In general the emery deposits are pockety and the workings are very shallow pits, from 2 to 10 ft. in diameter. A few, however, such as that noted above on McCoy's land, have shown a certain amount of persistency in depth, as well as in length.

III. Cryolite.

The importations of cryolite into the United States as in previous years, came from Greenland, and are given in the subjoined table. These shipments were made by the Pennsylvania Salt Manfacturing Co., of Natrona, Pa., which possesses the exclusive privilege to import this mineral into North and South America. The remainder of the output of the Ivigtut mines is shipped to Copenhagen.

IMPORTS OF CRYOLITE INTO THE UNITED STATES. (*a*)

Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.
1889..	8,603	$115,158	1892..	7,241	$96,932	1895..	9,425	$125,368	1898..	6,201	$88,501
1890..	7,129	95,405	1893..	9,574	126,688	1896..	3,009	40,056	1899..	5,879	78,676
1891..	8,298	76,350	1894..	10,684	142,494	1897..	10,115	135,114	1900..	5,437	72,763

(*a*) The values are those reported by the Custom House and represent the estimated cost at the mines. There being no United States Consul at shipping point in Greenland, a *pro forma* invoice is prepared for Custom House purposes, wherein the value represents only a small part of the actual cost at buyers' factory.

According to a report furnished by the Danish Government the total production in Greenland in 1898 was 8,150 metric tons, and in 1899, 8,874 tons.

The average price of cryolite in the American market during 1900 was 6·50c. per lb.

John D. Matthews and the British Aluminium Co.* have patented the following process for the manufacture of artificial cryolite. Fluorspar and sulphuric acid are heated to 100°C. with air agitation in a jacketed lead still. The distilled hydrofluoric acid is absorbed in potassium fluoride which is subsequently distilled, yielding pure hydrofluoric acid, the impurities remaining in the purifier as potassium sulphate and fluosilicate. Additions of proper quantities of aluminum hydrate and salt are made to the condensed hydrofluoric acid and the gelatinous cryolite formed is separated, washed, drained and dried.

In 1889 Dr. Charles A. Doremus secured a patent for the use of sodium fluoride in the softening of water. This chemical salt was not then procurable in quantities, but was later furnished by the Pennsylvania Salt Manufacturing Co., and is now made by the neutralization of soda ash with hydrofluoric acid obtained from fluorspar and sulphuric acid. A demand has been created for sodium fluoride and it is now exported to Europe and India. During the past year Dr. Doremus has patented† a process for obtaining fluorine from cryolite which contains 54% F. The cryolite is treated with steam at a sufficiently high temperature to cause a conversion of the fluorine content into hydrofluoric acid, leaving a residue of sodium aluminate in accordance with the following reaction:

$$Al_2F_6,\ 6NaF+6H_2O=12HF+Al_2O_3,\ 3Na_2O.$$

The escaping hydrofluoric acid may be collected as such or made to neutralize soda ash liquor, forming sodium fluoride. The proportion of water as steam to cryolite is as 108 to 420 or practically as 1 to 4. The silica of the quartz crystals which are disseminated through cryolite is evolved as silicon fluoride contaminating the acid slightly, but leaving a silicon-free alumina. The galena, siderite and iron pyrites also found in the cryolite in slight proportions are oxidized and the oxides remain undissolved on leaching out the aluminate. Consequently very pure alumina results. The process thus utilizes each of the important constituents of cryolite. After the trial of numerous mechanical methods whereby the steam could be brought into contact with the cryolite at the proper temperature, Dr. Doremus devised a furnace in which the powdered cryolite is subjected to the oxidizing flames issuing from a series of blow-pipe nozzles, in which natural gas or other fuel is burned directly against the cryolite. The charge is thus heated in contact with the steam resulting from the combustion. A patent for this furnace is now pending. It is the first of its type and is of very general applicability. This process is now being developed, but has not yet reached a commercial success.

IV. Aluminum.

The production of aluminum in the United States continued to increase during the past year, the total output amounting to 7,150,000 lb., against 6,500,000 lb.

* British Patent No. 11,963, June 8, 1899.

† United States Patent No. 660,024, Oct. 16, 1900, and for France, Belgium and other countries.

in 1899. There was a large demand for the metal in the electrical trade and as a substitute for brass and zinc for many purposes.

PRODUCTION, IMPORTS, AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year.	Production.			Imports.	Exports.	Consumption. (*b*)
	Pounds.	Value.	Per Lb.	Value.	Value.	Value.
1895	'900,000	$495,000	$0·55	$10,301	(*a*)	$505,301
1896	1,300,000	520,000	0·40	3,419	(*a*)	523,419
1897	4,000,000	1,400,000	0·35	4,731	(*a*)	1,404,731
1898	5,200,000	1,690,000	0·325	4,879	$239,997	1,454,882
1899	6,500,000	2,112,500	0·325	14,840	291,515	1,835,825
1900	7,150,000	2,288,000	0·32	47,688	281,821	2,053,847

(*a*) The exports from the United States were not reported by the Bureau of Statistics in these years. (*b*) The consumption each year includes a certain amount of manufactures imported; while the production represents the crude aluminum only. The bulk of the imports is in crude condition.

The statistics of aluminum production in Europe are not authoritative, several of the important companies being unwilling to make their figures public. The *Metallgesellschaft,* of Frankfort-on-Main, gives the following statistics for Europe in its last annual report, to which we have added our own figures for the United States, and those of C. Le Neve Foster for England in 1899.

ALUMINUM: WORLD'S PRODUCTION AND COMMERCE. (IN KILOGRAMS.)

Year.	Germany.	Switzerland.		England.	France.			United States. (*a*)		Total Production.
	Imports.	Production.	Exports.	Production.	Production.	Imports.	Exports.	Production.	Imports.	
1891		168,669	201,900	52,500	36,000	593	130	76,238	1,779	233,407
1892		237,395	277,900	41,000	75,000	2,007	42,287	133,811	20	487,206
1893		437,476	404,100		137,000	1,524	33,367	141,522	3,545	715,998
1894		600,000	520,200		270,000	2,958	30,787	370,860	2,405	1,240,860
1895		650,000	490,900		360,000	3,806	109,954	408,237	11,475	1,418,237
1896	591,500	700,000	661,100	130,000	370,000	7,012	192,763	589,676	316	1,789,676
1897	942,400	800,000	706,000	b310,000	470,000	6,300	224,000	1,814,388	854	3,394,388
1898	1,104,000	800,000	687,500	310,000	565,000	6,000	188,000	2,358,705	27	4,033,705
1899	922,000	1,300,000	617,500	559,000	763,000	8,000	256,000	2,948,381	24,323	5,570,381

(*a*) The United States has been an exporter of aluminum for several years, but these exportations were not enumerated by the Bureau of Statistics of the Treasury Department until 1898, in which year they amounted to $239,997. (*b*) C. Le Neve Foster, British Mineral Statistics for 1897.

PROGRESS IN THE ALUMINUM INDUSTRY IN 1900.

BY JOHN B. C. KERSHAW.

PRODUCTION.—On account of the refusal of the leading firms producing aluminum in Europe, to give official figures for their output of the metal, it is still impossible to arrive at any reliable estimate for the world's output of aluminum in 1899 and 1900. The 1899 output of the Pittsburg Reduction Co. has been estimated at 2,990 tons, an increase of 590 tons over the 1898 production; and the capacity of the two works at Niagara has been doubled by recent extensions, although the reported production during 1900 shows an increase of ten per cent. only. Steinmetz* estimates the world's production of the new metal in 1899 at 6,000 tons, and the 1900 production at 7,500 tons; but these estimates are admitted, by the author himself, to be untrustworthy.

* *Journal of the Franklin Institute,* May, 1900.

Matignon, in a recent report upon aluminum at the Paris Exposition,* estimates the 1900 output for all the works engaged in the production of the metal at 5,000 tons; and the writer from his own private inquiries is inclined to regard this estimate as more correct than the larger ones named above. However, until the European and American producers of aluminum show more trust in each other's returns, and are willing to give official figures for their production, no very reliable estimate is possible. As pointed out in THE MINERAL INDUSTRY, Vol. VIII., the six European aluminum works also make calcium carbide, and the proportion of the total power available, which is used for the manufacture of aluminum, is known only to those inside the works. Estimates based upon the horse power developed at the power generating stations, and used in the works or factory, are therefore valueless. Whether the striking fall in the price of calcium carbide which occurred during 1900, has had any effect upon the relative output of calcium carbide and aluminum by these works, cannot yet be decided. Calcium carbide selling at $48 per ton at Hamburg, cannot leave much margin of profit for the producers, and therefore it is natural to assume that a greater proportion of the power available at these six works has been used for the production of aluminum.

During 1900 the number of aluminum works in operation has been increased by one, and the total number is now eight. Details of these are given below:

TABLE I.—DETAILS OF ALUMINUM WORKS IN EUROPE AND AMERICA.

Name of Company.	Locality of Works.	Horse Power.		Process.	Capital.
		Available.	In Use. (a)		
1. The Pittsburg Reduction Co.	No. 1, Niagara Falls		10,000	Hall	
2. The Pittsburg Reduction Co.	No. 2, Niagara Falls.			Hall	
3. The British Aluminium Co.	Foyers	14,000	5,000	Herault	$3,360,000
4. Société Electro-metallurgique Française	Le Praz	12,500	5,000	Herault	2,880,000
5. Compagnie des Produits Chimiques d'Alais	St. Michel	6,000	2,000	Minet & Hall	
6. Société Anonyme pour l'Industrie de l'Aluminium	Neuhausen	4,000	4,000	Herault	3,077,000
7. Société Anonyme pour l'Industrie del'Aluminium	Rheinfelden	5,000	5,000	Herault	
8. Société Anonyme pour l'Industrie del'Aluminium	Lend-Gastein	5,000		Herault	
	Total		31,000		

(a) With the exception of the works at Niagara Falls, N. Y., all these works produce calcium carbide in addition to aluminum.

The new works is owned by the Société Anonyme pour l'Industrie de l'Aluminium, and is situated at Lend-Gastein on the river Achen in Austria. Calcium carbide is also manufactured at this works, and since manufacturing operations were commenced early in 1900, there have been one or two serious break-downs of the machinery. A fall of 63 m. is obtained at this place, and a power-plant of 5,000 H.P. has been constructed.

At Niagara Falls, the Pittsburg Reduction Co. has increased its plant by the addition of four new generators, and the two works now have a total capacity of 10,000 H.P. The original works of this company at New Kensington, Pa., now used for rolling the metal produced at Niagara Falls, were damaged by a tornado in August, 1900, but the financial loss from this cause was less than at first supposed. The two French works at Le Praz, and St. Michel have not undergone any important extensions in 1900. The latter works is now owned

* *Moniteur Scientifique*, August, 1900.

and worked by the "Compagnie des Produits Chimiques d'Alais," formerly Pechiney et Cie, the chemical firm who first manufactured aluminum in France by the older chemical process. The generating machinery at Le Praz has recently been very fully described* by Laponche; but no details of the electro-metallurgical process have been given in this article. The most interesting feature of the hydraulic plant, is the manner in which the pipe-line is carried over the river Arc near the power house without any support, the pipe-line itself being made to spring from buttresses and to carry its own weight. The article fully illustrates this novel feature of the installation.

As regards future developments in connection with the aluminum industry, works are now being erected at Shawinigan Falls in Canada, and it is expected that a 5,000 H.P. plant will be in operation in 1901. This works is being built under the superintendence of the Pittsburg Reduction Co. The projected works at Almissa in Austria, and at Sarpsfos in Norway, are still incomplete.

The Neuhausen Aluminium Co. continues to be the most profitable of the European companies engaged in the industry, and in 1899 it paid 13%, as compared with 12% in 1898; the French company paid 7%; while the British Aluminium Co. has only succeeded in paying part of the dividend on its preference capital. The discussion of the causes of this difference in the dividend earning power of these three companies, is outside the scope of this article. The dividend of the Pittsburg Reduction Co. has not been ascertained.

No new process for the production of aluminum has been developed industrially during 1900. The Peniakoff process, which the writer was informed in 1899, would be worked at Selzalte in Belgium, and at Givors in France, has retired into obscurity, and only alumina and its salts are produced at these two works. The criticisms passed upon this process when it was first made public, are therefore justified.

Regarding the actual details of the process of manufacture as carried out in the different works, little additional information has been published during 1900. Kingman† has stated that the pots now in use at Niagara Falls for aluminum production are of 0·25 in. boiler-plate, with a carbon lining from 4 to 6 in. thick, and are 5 ft. long, by 2·5 ft. wide, by 2 ft. deep. Two copper bars run above each pot, and to these are clamped 10 carbon electrodes. Each pot is said to require an E. M. F. of 9 volts, and to produce 60 to 70 lb. aluminum per day. The temperature of the bath is kept below 982°C. The energy efficiency of the process is stated by Kingman to be 27%. It is not evident whether this information has been gained during a personal visit to the works, or whether it is a slightly varied version of facts previously published. If the voltage named above be correct, this efficiency does not agree with that calculated by me in 1897;‡ namely 29% for an E. M. F. of 5·5 volts per bath, and an output of 0·617 kg. aluminum per E.H.P. day. During 1900, Prof. Chandler of Columbia University has also given some details of the procedure at Niagara Falls.§ According to this authority the pots exhibit a cavity 4·5 ft. long by 2·5 ft. wide by 6 in. deep. Each pot contains 40 anodes arranged in four rows of ten.

* *Le Genie Civil*, June 23, 1900.
† *Western Electrician*, March 17, 1900.
‡ *Electrician*, Feb. 5, 1897.
§ *Journal of the Society of Chemical Industry*, July, 1900.

Each anode is a cylinder of carbon, 3 in. in diameter, and 18 in. long when new. The works referred to by Prof. Chandler (it is not stated whether it was works No. 1 or No. 2 at Niagara Falls), contained 100 pots—and each of these pots is estimated to yield 100 lb. aluminum per 24 hours. This gives an output of 7,500 lb.=3·45 tons of the metal per day, or 1,242 tons per year, on the assumption that 75% of this number are kept constantly at work.

The selling price of aluminum has undergone little alteration during 1900, and as pointed out in the last report,* for the higher grades of the metal little reduction in price can be expected by the present methods of manufacture. In December, 1900, 99% aluminum was being quoted at 33c. per lb. at Niagara for large orders of over one ton; a price which is practically the same as that ruling in 1899. Prof. Richards† has stated that the selling price was 25c. per lb. in Europe and 30c. in the United States, but it is probable that the difference of 3c. per lb. is due to the different grades of the metal to which these prices refer. Steinmetz‡ indulged in the hope that aluminum would be sold for 15c. per lb. in 1910, and for 10c. per lb. in 1925; but this enormous reduction in price can only be attained by radically different methods of manufacture. At present the cost of the purified alumina with which the baths or pots are fed, is the main item in the cost of production; and until it is possible to dispense with the purification of this raw material, it will be impossible to effect any important saving in the process of manufacture. An electrolytic process for purifying crude aluminum similar to that used in the copper industry would help to solve the problem; but hitherto all attempts to deposit aluminum electrolytically from aqueous solutions have failed. At the Paris Exhibition in 1900, it is true that a sample of aluminum sheet was shown, which it was stated had been obtained by such a process, but no details of the discovery have been published, and Dr. Borns, who reports it,§ adds that the claim was received with incredulity. The nearest approach to the low prices named above at present, is for a very low grade metal (90% Al), which one of the French works has undertaken to supply for use in the Goldschmidt thermal reduction processes. The price charged for this impure metal is 2 fr. per kg. or 17·4c. per lb.‖

With regard to the prices charged for aluminum drawn into rod or wire for conducting purposes, the Pittsburg Reduction Co. is still reported to be selling large quantities for overhead transmission lines at 29c. per lb., at the point of consumption. In England £170 per ton (36·4c. per lb.) is being asked for wire intended for similar use. The writer has already stated his belief that the former price leaves little margin of profit for the manufacturer. This opinion is supported by Prof. Richards' estimate, that the lowest cost of production for ingot aluminum at present is 20c. per lb. to which must be added, rolling, drawing and annealing costs, and freight to the point of use. These probably amount to over 9c. per lb.; but as pointed out in THE MINERAL INDUSTRY, Vol. VIII., p. 21, the policy of the Pittsburg Reduction Co. in selling at a loss may eventually prove wiser than that of the European pro-

* THE MINERAL INDUSTRY, Vol. VIII., p. 21. † *Journal of the Franklin Institute*, June, 1900.
‡ *Ibid.*, October, 1900. § *Engineering*, Nov. 30, 1900. ‖ *Moniteur Scientifique*, August, 1900.

ducers, who are selling aluminum for electrical purposes at a much higher figure.

The question of patents during 1900 has attracted attention only in England in connection with the application of the British Aluminium Co. to the English courts, asking for a prolongation of the normal period of 14 years for Herault Patent No. 7,426 of 1887. It is doubtful whether this claim will succeed, although the British Aluminium Co. did not begin to work the Herault process until 1896—nine years after the patent application was filed. If the application fails, its monopoly of manufacture will expire in 1901; but it is doubtful whether any other company will take up the manufacture in the United Kingdom under the present conditions of the industry.

In the United States, the year has been signalized by the delivery of the judgment of the Supreme Court, in the protracted litigation over the Bradley patents. The Cowles Co., who own the Bradley patent rights, have been successful, and all companies carrying on electric furnace operations in America, will now have to obtain licenses from the Cleveland Electric Smelting Co., or to close their works. Whether this alteration in the patent situation in America will add to the cost of manufacture remains to be seen; but it is interesting to note that the Bradley patents themselves expire in 1903, while the Hall patents do not expire until 1906. The check which this decision of the Supreme Court can exert upon the development of the industry is therefore likely to be slight, and its chief effect will be a depletion of the cash reserves of the companies concerned, should the decision be made retroactive.

UTILIZATION.

Electrical Conductors.—A large amount of information concerning the various aluminum transmission lines already erected in America and elsewhere, was given by me in THE MINERAL INDUSTRY, Vol. VIII., p. 23, and it is unnecessary to repeat the details here. Although the use of aluminum for electrical work must still be considered an experiment, new installations of the light metal are being constructed. Prof. Richards states that over 500 tons was used for this purpose in 1899, and that double this amount will be consumed in 1900. One of the most important of these new lines is that in connection with the Manhattan Elevated Railroad of New York City. Owing to the continued high price of copper, it has been decided by this company to use aluminum for all the conductors on the reconstructed railroad.

Another important scheme for which aluminum is to be used is the extension of the Power lines of the Telluride Power Co. at Provo, Utah, where an 80-mile circuit exists.

Very full details of the construction work for laying the aluminum feeders on the Northwestern Elevated Railroad of Chicago, have been published during 1900. One hundred and fifty thousand pounds aluminum have been used for this work, principally as 1·5-in. cable. Each cable contains 49 strands aluminum wire, the wires being grouped in sevens. The aluminum is soldered to copper at the terminals, where it joins the underground mains.* Sir William Preece stated in

* *American Electrician*, January, 1900.

a lecture before the Institution of Civil Engineers in London in April,* that he had recommended the use of the new metal for telegraph lines in Central Africa, and that the post-office authorities in England were using it for telephone work. Perhaps the most striking of the new developments in connection with the use of aluminum as an electrical conductor is that proposed by the Standard Electric Co., of San Francisco, which intends to erect a generating station at the foot of the Sierra Nevada Mountains and to transmit power from this station, 156 miles to San Francisco, over an aluminum cable at 60,000 volts pressure. The cables are to be stranded, each consisting of 37 strands.† A capital outlay of $2,000,000 is contemplated, but whether this will cover the whole cost of the generating plant and transmission lines, is doubtful.

Steinmetz in the paper already quoted,‡ states that the Chicago Fire Alarm Service is making experimental trials of aluminum on its telephone lines, and that the metal was used in Cuba in 1899 for field telegraph work. For commutator bars the new metal has not answered.

The managing director of the British Aluminium Co. has informed me that the company has had about 35 tons of the metal in use at the Foyers works for transmitting purposes for three years; and that up to the present time no visible deterioration can be marked.

Trials of the new metal have been made by the postal and telegraph authorities in France, but according to Matignon§ the results have not been so encouraging as those obtained across the Atlantic.

At the Rheinfelden works of the Société Anonyme pour l'Industrie de l'Aluminium, aluminum is used to carry the power from the generators to the works; but the distance is only short.

During the past year a large number of reports concerning the condition of the existing aluminum lines after some months' exposure have been published. Thus it was reported in January that both the Snoqualmie Falls lines, which have been operating one year, were giving satisfaction; and that the Telluride Power Co., of Denver, was so pleased with the behavior of the new metal, that it intended to increase its use of aluminum for overhead lines. It was admitted in this report, however, that the Pacific States Telegraph & Telephone Co., which had over 200 miles of aluminum wire in use, had experienced annoying breaks at first; but these breaks are now attributed to bad lots of wire.‖ Prof. Forbes, in his paper on "Power Transmission," read before the Institution of Electrical Engineers in London in February, 1900,¶ stated that the Westinghouse Co., who had used the new metal for the Tacoma-Seattle line, when asked to specify its use for the projected Mysore power scheme in India, refused on the ground that the trials hitherto made were experimental only. Prof. Forbes gave it as his own opinion, that aluminum wire used for overhead work would require painting, in order to obtain the desired resistance to corrosion. Messrs. Perrine and

* *Proceedings of the Society of Civil Engineers*, 1900.
† *Electricity*, New York, May 23, 1900.
‡ *Journal of the Franklin Institute*, October, 1900.
§ *Moniteur Scientifique*, August, 1900.
‖ *Aluminum World*, January, 1900.
¶ *Proceedings of the Institute of Electrical Engineers*, London, 1900.

Baum in May, read a very valuable paper upon the Blue Lakes power transmission line before the American Society of Electrical Engineers.* The following is an abstract of their paper:

The line was 43 miles long and the transmission system three-phase. The wire used tested 59·9% conductivity as compared with copper of the same dimensions, and had a tensile strength of 14·6 ton per sq. in. The tensile strength was therefore 0·629 that of copper for the same conductivity and the weight 0·501 that of copper. A permanent load of 14,500 up to 17,000 lb. per sq. in. is the maximum one for such a wire. The instructions to the line foremen for stringing the wires are given in full. The joints are mechanical, aluminum sleeves being used. The wire was erected in the winter of 1898-99. Three breaks occurred before the current was transmitted, but these were due to flaws in the material. After this no further breaks occurred, but in January, 1900, the whole line was taken down and replaced by one of heavier wire; 1,000,000 lb. of 0·75-in. cable were used. Other lines erected on the Pacific Coast during the last two years have with one exception proved troublesome. Some of the breaks recorded have been due to insufficient allowance for temperature changes. The telephone company in Washington and Oregon, and the Yuba Power Co., have met with such trouble from their aluminum lines that they are replacing them. Perrine and Baum think these breaks are due to impurities in the aluminum. The total resistance of the line just described was in fact 10% higher than calculated, a certain proof of impure metal in some sections of the line. The authors close their paper by restating their belief in the future of aluminum as a conductor, when rightly used.

Canfield, in the papers named below,† gives some interesting information concerning the aluminum trolley line on the Kansas City & Leavenworth Electric Railroad; 76 miles of 0·75-in. cable have been used. Some of the joints in this cable were made with bronze clamps with corrugated internal surfaces; others were made with clamps filled with a tin-lead solder. No break-downs had occurred at the date of this report; but the latter method of joint making cannot be recommended.

E. B. Elliott, of Chicago, reports‡ that the aluminum telegraph wires in that city under his observation, had stood the winter of 1899-1900 well, and that the few breaks which had occurred were due to defective stringing. Two miles of wire were in use, and 10 miles more were to be erected. At Northallerton, England, four miles of aluminum wire are in use in connection with a small electric lighting station. The joints are made by screwed sockets of brass,§ and the company owning this installation report in October, 1900, that no breaks have occurred.‖

The transmission circuit of the line of the Telluride Power Co.¶ forms a triangle, two of the sides of which are of aluminum, and the third of copper. The power transmitted is 1,500 kw. at 40,000 volts. The loss is said to be only 4%. One of the aluminum sides of the triangle crosses a mountain range, and

* *Electricity*, New York, May 30, 1900.
† *Aluminum World*, April and July, 1900.
‡ *Idem*, May, 1900.
§ *Electro-Chemical Review*, June, 1900.
‖ *Electrician*, Oct. 26, 1900.
¶ *Electrical World*, July, 1900.

is frequently lost to view in clouds. Winds also blow up from the plains, and coat the poles and lines with salt dust, yet no ill effects have been caused by these adverse conditions. A 60,000-volt line is now planned by this company.

The Snoqualmie Falls Power Co. during 1900 has carried out an interesting experiment in long distance transmission.* By coupling all its lines in series, it obtained a line 154 miles in length, and over this distance it transmitted 530 kw. The initial voltage was 24,000 volts, and this dropped to 18,000 volts at the receiving end of the line. The loss was therefore 25%.

Military Outfits.—The use of aluminum for the various vessels which make up military camp outfits progresses slowly; but during 1899-1900 a small boom occurred in England in this branch of the industry, owing to the demand for officers' outfits in connection with the South African war. This boom was accentuated by the army order reducing the total weight of officers' kits to 45 lb. Some interesting reports upon the condition of these aluminum vessels after 12 months' service in the field, ought therefore to appear shortly. The Pittsburg Reduction Co. is reported to have sold 45 tons of the new metal to the Japanese Government for military purposes. According to *Sells Commercial Intelligence* the military authorities in Russia, Japan, and Germany, have adopted aluminum for military water bottles; in the latter country it is stated to have been adopted for camp kettles also. This report is obviously incorrect, for a complete equipment of the armies of Europe with aluminum water bottles, would require hundreds of tons of the metal, and is only likely to occur gradually. With regard to the corrosion of aluminum when used for boiling water, Prof. Richards, of Philadelphia, has published some interesting notes. He states that an aluminum kettle has been in use in his house for seven years. This kettle is now coated inside with a brown skin of oxide, which is left intact, and this skin has no doubt served to protect the metal beneath. Apart from this skin of oxide, the kettle is as perfect as upon the day it was first used.† An exhibit which attracted some attention at the Paris Exposition was that of an aluminum water distilling apparatus—the vessel being 2 m. in diameter—by the British Aluminium Co. It is not known whether any stills of this size are in actual use.

Boat Building.—The use of aluminum for boat building and marine engineering has not progressed in 1900. Its employment for the internal metal work decoration of cabins and saloons is however extending, and the British Admiralty is said to have authorized its use for this purpose. The United States naval authorities‡ have used aluminum for certain portions of two of their latest torpedo boats; but the details of this use have not been divulged. A steam yacht of 60 tons rating has been built in 1900 by Ayres, of New York, with aluminum frames and deck plating,§ but doubtless in this case some protective coating or covering has been used. Perhaps the most notable use of aluminum during 1900 for boat building has been in connection with Count Zeppelin's air-ship. This air-ship, which has made two fairly successful aërial trips, is 416 ft. long and 38 ft. in diameter. Its lifting power is 10 tons, and this is obtained by 17 balloons inflated with hydrogen gas; the balloons being enclosed in a frame of aluminum

* *Western Electrician*, Oct. 27, 1900.
† *Journal of the Franklin Institute*, June, 1900.
‡ *Aluminum World*, November, 1899.
§ *Idem*, February, 1900.

trellis work.* Steinmetz, in the paper already quoted,† states that the aluminum plates used in the construction of the racing yacht, Defender, were all painted with a special composition. Some of these plates are badly corroded, but the greater number have lasted well. As regards the new yacht now being built at Glasgow for the 1901 Cup Contest, no information has yet leaked out, concerning the use of aluminum. It is however certain that the new metal will not be used for the upper spars,—an accident similar to that which befell the Shamrock in 1899, cannot again be risked. Matignon, in his report upon aluminum, at the Paris Exposition, gives some interesting information relative to the use of aluminum for boat building purposes by French builders.‡ The torpedo boats Foudre and Forban are stated to be now corroded and worthless, in spite of repeated paintings. On the other hand excellent results have been obtained with boats built of the new metal for exploring expeditions. The Etienne was built in 1893 with plates of an alloy containing 96% Al and 4% Cu. This boat carried Marchand down the Nile to Fashoda in 1898, and is still in existence. The Jules Davoust is another boat built in the same year. It has returned to France after covering 3,600 km. Its frame, though built of impure aluminum, is still in an excellent state of preservation. It must be noted that these boats were used solely upon fresh water rivers and upon inland seas, and their preservation is to be ascribed to the absence of dissolved salts in those waters.

Cycles and Motor-Cars.—Although the use of aluminum in the cycle industry makes no progress, the allied motor-car industry promises to give an important outlet for the new metal and its alloys. In England many trial orders for aluminum are being placed in connection with the industry, and in France the use of alloys of the light metal for motor-car building has already passed the experimental stage. "Partinium" is the alloy most favored by French builders for this purpose, and it is also being used for the construction of ordinary horse vehicles. The weight of the carriage is said to be reduced 30%, at an addition to its cost of only 16%. In the automobile industry the parts constructed of aluminum or its alloys which may be exposed, are covered with a film of oil as a protection from salt air, rain, or dust.

Printing.—The use of aluminum plates in rotary presses for lithographic work is extending. Over 35 firms in the United States are now using these plates in their printing works. To this number must be added 2 in Canada, 5 in England, 1 in France, and 1 in Japan, while in Germany, where the process first received trial, there are, it is reported, 100 firms using the new method. In January, 1900, the *Aluminum World* published a special number on this new application of the metal, which included articles by Wagner and by other authorities upon "Algraphy," as the new method of printing is called.

Properties.—Prof. Henry M. Howe in his report on metallurgy at the Paris Exposition of 1900 gives the following record of the properties of aluminum and aluminum alloys: Specimens manufactured by the Société le Ferro-Nickel: Tensile strength 12,800 to 14,200 lb. per sq. in., elastic limit 8,500 to 9,200 lb. per sq. in. with 25% elongation. Aluminum alloys prepared by Maxime Corbin,

* *Aluminum World*, September, 1900. † *Journal of the Franklin Institute*, October, 1900.
‡ *Moniteur Scientifique*, August, 1900.

Paris: Small objects, tensile strength 20,000 to 25,300 lb. per sq. in., elongation, 2 to 9%; large objects, 23,700 to 28,400 lb. per sq. in., elongation 0·25 to 3%.

Metallurgical Reduction.—The use of aluminum as a reducing agent and for general foundry work is extending, the cheaper grades of aluminum being employed for many of these purposes, since the presence of iron and silicon is of no importance. The offer of the French aluminum companies to sell 90% Al for reducing work at the low price of 17·4c. per lb. has already been noted—but grinding the aluminum to powder adds very considerably to its cost. Powdered aluminum is employed in the Goldschmidt process for obtaining high temperatures, and for reducing refractory oxides. This process has been attracting unusual attention during 1900, and formed the subject of one of the papers at the Paris meeting of the Iron and Steel Institute.* Little additional information concerning this process was given in the paper alluded to beyond statements as to its cost when used for welding purposes. Prof. Richards, in discussing this process,† stated that Tissier, Wahl, and Greene, were the first to use aluminum for reducing purposes experimentally; and Vautin has also pointed out‡ that he had patented and used a similar process in England before Goldschmidt turned it into a practical success. Goldschmidt's services in connection with this new process were in showing under what conditions it could be made self-supporting, and in the invention of a simple means for starting the reaction between the powdered aluminum and the oxide. Prof. Richards states that the method is now being used at Philadelphia for the production of ferrochromium and ferromanganese alloys, in addition to its use for similar purposes at Essen, Germany, and in France.

The writer has not been able to learn of any similar works in the United Kingdom.

Melland and Waldron have contributed to the Paris Congress a paper dealing with their experiments upon the use of aluminum for removing the carbon in cast-iron; but these do not appear to have led to any practical result, as large percentages of the light metal were required to effect complete removal of the carbon.

Miscellaneous Uses.—In the construction of the new Waverly Station at Edinburgh aluminum has been used for some of the interior ornamental metal work. The Bay State Aluminum Co. of the United States has recently made 500 telephone receivers with the metal. A new use for aluminum is in the construction of stock patterns for foundry work. When made of wood these patterns soon require renewal, but when made of aluminum they possess both lightness and durability. The Eastman Photographic Co. is using the new metal for the framework of its new pocket folding kodak. According to Prof. Richards aluminum is superseding zinc as a covering for fruit jars. Though the caps of aluminum are more expensive, they are less dangerous than those of zinc. The metal is also being used in place of silver-leaf for decoration, as it can be beaten out into leaf only 0·0000143 in. in thickness. Ground to powder, the leaf can be used for obtaining similar decorative effects, either in

* *Engineering*, October, 1900. † *Journal of the Franklin Institute*, June, 1900.
‡ *Electrical Review* (London), Aug. 19, 1898.

printing or painting. Powdered aluminum costs $1·25 per lb. The dangers that arise during the grinding were noticed in THE MINERAL INDUSTRY, Vol. VIII.

Aluminum is being drawn into tubes by the Elwood Ivins Co. of the United States, and tubes from 4-in. down to 0·026-in. diameter are being produced. In the latter case the metal is only 0·0015 in. thick.

According to Steinmetz, the light metal is now being used for samples in the hardware trade, the idea being to reduce the weight which travelers in this trade are obliged to carry. In the United States the new metal was tried for bath-tubs, but this use has not been a success; and its use for the manufacture of thimbles is also said to have failed. The manufacturers of combs, hairpins, brushes, and similar toilet articles, as well as those of small ornamental boxes and frames, have found the new metal well suited to their requirements, and the consumption of aluminum in these small manufactures is a growing one on both sides of the Atlantic. In England the British Aluminium Co. has induced the makers of electric fan ventilators to adopt the new metal, and water fittings (taps, cocks, etc.,) of aluminum are being used experimentally by some of the water-work companies, and by a noted firm of fire-engine builders. In France aluminum has been applied by Corbin et Cie for the construction of parts of the carriages of field guns.

Soldering Aluminum.—During 1900 the increasing use of aluminum in electrical transmission work has emphasized the need for a good and permanent solid joint, and several solders have been brought before the public. Good results are said to have been obtained with a solder composed of tin, zinc and bismuth, invented by Prof. Irving, of Illinois.* In my opinion no composition of this kind is likely to give a permanent joint with aluminum when exposed to a wet, or to a damp, atmosphere. Under such conditions electrolysis is bound to occur. For this reason, the autogenous method of joining aluminum, described and patented by Heraeus, of Hanau, in Germany, is worthy of attention.† This method depends upon the fact that at a certain temperature aluminum becomes plastic and can be kneaded into any shape. The pieces to be joined are raised to, and maintained at, this temperature, and while so heated are kneaded together. This method can be applied both to wires and to sheets. At the Paris Exposition an aluminum wire 5 ft. long, constructed of 12 different pieces, was shown. Heraeus states that a closed vessel of 27 cu. ft. capacity has been made out of five pieces of aluminum plate 10 mm. thick, by this process, and has stood a test of 5 atmospheres' internal pressure without showing any leak. It is expected that the success of this method of jointing aluminum will lead to an extension of its use for vessels in chemical and similar works.

The report of the inventions by which aluminum can be deposited from aqueous solutions or by which articles can be electroplated with the new metal, must be accepted "*cum grano salis.*" Legate, of Hartford, Conn., is turning out small objects of fine finish, plated with the new metal, but his process is probably a mechanical one. The piece of sheet electro-deposited aluminum shown at the Paris Exposition has already been mentioned.

* *Aluminum World*, January, 1900. † *Zeitschrift für Angewandte Chemie*, July 24, 1900.

Alloys.—There has been an increase of interest in the alloys of aluminum during 1900, and the composition of several new alloys has been published. Lawson, of Glasgow, has invented an alloy called "Rex" metal, which is said to resist the action of salt water. The Delaware Metal Refining Co. of Philadelphia is making an alloy of sp. gr. only 3·1, which is said to be as strong and rigid as gun metal and the ordinary bronzes. The alloys of copper, zinc and aluminum invented by McAdams, and of "Partinium" (an alloy of aluminum and tungsten), were fully described in THE MINERAL INDUSTRY, Vol. VIII.

Prof. Carpenter, whose alloy of copper, zinc, and aluminum was referred to in Vol. VIII., has during 1900 patented a new alloy of the light metal.* This alloy contains 50% Al, 25% Sn and 25% Zn. Its sp. gr. is 3·3, its tensile strength is 26,000 lb. per sq. in., and its elongation is 8%. In England, aluminum bronze, containing 3% Al, is being used for the tubes of water-tube boilers. For the reasons given above I consider this rather a dangerous use of the new metal; and the report of the life and behavior of these tubes will be awaited with some interest. At the Paris Exposition a screw propeller—2·59 m. in diameter—constructed of aluminum bronze—was shown by the British Aluminium Co. The strength of the alloy is stated to have been 54 kg. per sq. mm. (equals 76,544 lb. per sq. in.); but if this strength has been gained at the expense of its resistance to corrosion, the gain is a dubious one. The report of the German Admiralty upon the corrosion of alloys in sea water (abstracted in THE MINERAL INDUSTRY, Vol. VIII., p. 28), shows that these aluminum bronze alloys are easily attacked, when in electrical contact with more electro-negative metals or alloys.

"Albradium" is a new alloy of aluminum containing copper, nickel, zinc, phosphorus, and aluminum. It takes a polish equal to silver, and a company has been floated in France to take up its manufacture. The alloys made by the Société des alliages Cothias are intended for the manufacture by casting, of the finer and more delicate parts of machines and instruments, hitherto made by hand. These alloys contain tin, copper, zinc, and aluminum, and vary in sp. gr. between 2·8 and 7·1. Their tensile strength lies between 12 and 22 kg. per sq. mm. (17,028 to 31,218 lb. per sq. in.). Their melting point is below 800°C. "Magnalium," an alloy of aluminum and magnesium, was referred to in THE MINERAL INDUSTRY, Vol. VIII. A company has been formed to push its manufacture and sale in France, and it is expected that when the cost of production has been reduced by the increased output of magnesium, the new alloy will to some extent displace brass in ornamental metal work.

Properties.—Mr. Ellicott, of Chicago, has published tests of the tensile strength of the aluminum wire used experimentally for telephone purposes on the fire alarm circuits of that city.† No. 10 gauge wire had a tensile strength of 275 lb.; and weighed 51·5 lb. per mile. The comparative figures for No. 10 hard-drawn copper wire were, 515 lb. and 173 lb. respectively. New facts bearing upon the discussion between Moissan and Ditte, as to the resistant properties of the new metal to corrosion, when exposed to the atmosphere (see THE MINERAL INDUSTRY, Vol. VIII.), have been published by Prof. Richards and myself during

* United States Patent No. 652,833, July 3, 1900.

† *Electrical Review* (London), Jan. 12, 1900.

1900. The remarks of Prof. Richards upon the corrosion of aluminum kettles when used for boiling purposes have already been mentioned.

In January, 1901, I read a paper dealing with results of exposure tests of aluminum and other wires, before the Institution of Electrical Engineers.

Two sets of sample wires—each wire 24 in. in length and properly insulated from electrical contact with its neighbor—were submitted to exposure for 10 months in 1899-1900. The localities chosen for exposure were Waterloo and St. Helens, two towns in South Lancashire, England. The samples comprised all the metals and alloys now being used for bare overhead conductors. Each wire was carefully weighed before and after exposure.

The results of these weighings are given in Table I.

TABLE I.—RESULTS OF EXPOSURE TESTS OF ALUMINUM AND OTHER WIRES.

Composition and form of sample.	Waterloo set; 10 months.		St. Helens set; 10 months.	
	+ = gain − = loss in weight.	Remarks.	+ = gain − = loss in weight.	Remarks.
	%		%	
Aluminum rod No. 1....	*Nil.*	These 5 samples were all pitted, especially on the under sides, where water-drops had collected and dried.	+ 0·27	These 5 samples were very badly pitted. Dirt had settled in their corrosions and could not be removed by scrubbing.
No. 2.....	+ 0·13		+ 0·51	
Aluminum wire No. 1...	+ 0·41		+ 0·83	
No. 2.....	*Nil.*		+ 0·83	
No. 3.....	+ 0·55		+ 0·54	
Galvanized iron wire				
No. 1.....	− 0·15	No change in appearance to the eye.	− 1·44	Badly corroded.
No. 2.....	− 0·16		− 2·13	Zinc partly eaten away.
Copper wire No. 1.....	*Nil.*	Oxidized on surface, but not pitted or corroded.	− 1·65	These wires were perfectly black, and could not be distinguished.
Tinned copper wire No.1	*Nil.*		− 1·31	

The weights of the wires—in the case of aluminum—gave no information as to the extent to which the metal had suffered by the exposure, and one of the sample wires of aluminum was therefore withdrawn from further exposure tests, and was submitted to physical tests, for conductivity and tensile strength. The results are given in Table II.

TABLE II.—TESTS OF ALUMINUM WIRE FOR CONDUCTIVITY AND TENSILE STRENGTH.

Material.	Conductivity; copper 100.	Tensile strength; tons per square inch.
Original wire.....	51·3	13—16
Waterloo sample.....	51·4	12·06
St. Helens sample.....	46·6	11·15

These results prove that aluminum when exposed to atmospheric influences without any protective coating, is badly attacked, and that the corrosion is greater in smoky and sulphurous atmospheres, such as those found in large manufacturing towns, than in country districts. The experiments are being continued, and it is hoped that similar exposure tests will be instituted in other places, in order that adequate scientific data on this question of the resistance of metals and alloys to atmospheric corrosion in various climates may be collected.

Raw Materials.—It is reported that extensive beds of bauxite have been discovered in New South Wales, Australia. The best samples of this bauxite

analyzed 58% Al_2O_3, and it is therefore of good quality. Bauxite is an impure hydrate of aluminum. The aluminum made in the eight factories producing the metal, is made from purified alumina, obtained from bauxite by dissolving out the alumina with soda and precipitating the same by carbon dioxide gas or by heating under pressure. The process is costly and troublesome, but it is the only one that has achieved practical success on a large scale. That there is room for new processes is proved by the heavy item which "raw materials" form, in the cost of manufacturing aluminum.

The details of three new processes for obtaining alumina from the raw materials, have come under the writer's observation during 1900. The first is that of Rothberg, of Pennsylvania.* Clay is treated with sulphuric acid and the mass then leached with water to remove the aluminum sulphate formed by the reaction. The solution after filtering is treated with bleaching powder. The following reaction occurs:

$$Al_2(SO_4)_3+3Ca(OCl)_2=3CaSO_4+Al_2Cl_6+3O_2.$$

The solution of aluminum chloride is then treated with caustic lime and the alumina precipitated as hydrate. It is not known whether this process is yet being worked on a practical scale.

At Selzaete, in Belgium, and at Givors, in France, alumina is extracted from bauxite by the Peniakoff process.

Bauxite containing 60% Al_2O_3 and only 3% SiO_2 is mined near Tourves, in the Province of Var. The deposits at this place are said to exceed 200,000 tons. It is mixed with sodium sulphate and iron sulphide and is heated in a closed furnace. The following reaction occurs:

$$3\{(Al_2O_3)_4,Fe_2O_3\}+12Na_2SO_4+5FeS=12\{Al_2O_3,Na_2O\}+17SO_2+11FeO.$$

The sodium aluminate is separated by washing and may be decomposed by treatment with carbon dioxide gas—when alumina and sodium carbonate are obtained. The sulphurous acid gas evolved by the primary reaction is used to recover a corresponding amount of sodium sulphate by passing over sodium chloride. Sodium carbonate and lime are the two by-products of the process, and both are of considerable value. The works at Selzaete and at Givors each employ 100 to 120 people, and the manufactory at the latter place is enabling France to meet her own requirements of alumina and its salts. It does not appear, however, that the use of sodium sulphate in place of sodium hydrate has had any great effect in cheapening the cost of pure alumina, for the Peniakoff process is not yet adopted by the aluminum works for preparing their raw material.

The third method is also patented,† and is described in the paper named below.‡ The bauxite is crushed and is heated with alkaline sulphides. The alkali salts are then removed by washing, the insoluble residue is suspended in water, and sulphurous acid gas is passed through the mass. A solution of aluminum sulphite is obtained, and after decanting form the insoluble gangue, etc., it is heated to boiling. Basic aluminum sulphite is precipitated and sulphurous acid gas is

* United States Patent No. 657,453, 1900. † Russian Patent No. 3075, 1898. ‡ "*Chemiker Zeitung*," Oct. 10, 1900.

liberated. The precipitate is collected, washed and dried. On heating, the remaining molecules of sulphurous acid escape, and alumina (Al_2O_3) remains. The sulphurous acid gas is collected, and used again in the process, which is to some extent a cyclic one. If iron be present in the raw materials used, special precautions are necessary to prevent contamination of the end product (Al_2O_3) by this impurity.

V. Alum and Aluminum Sulphate.

Alum, Artificial.—The consumption of alum in the United States in 1900 increased, and its production is now under the control of a few concerns, the two largest being the Pennsylvania Salt Manufacturing Co. and the General Chemical Co. The former manufactures alum from cryolite, while the latter uses Greenland cryolite.

UNITED STATES PRODUCTION AND IMPORTS OF ALUM.

Year.	Production.								Imports. (a)		
	Alum.			Aluminum Sulphate.			Total Reckoned as Alum. Sh. Tons.	Total Value.	Short Tons.	Value.	Per Ton.
	Short Tons.	Value.	Per Ton.	Short Tons.	Value.	Per Ton.					
1897..	15,456	$463,680	$30·00	46,355	$1,158,875	$25·00	79,600	$1,622,555	2,373	78,883	$33·24
1898..	18,791	563,730	30·00	56,663	1,416,675	25·00	97,302	1,980,405	(b) 893	16,187	18·13
1899..	27,276	845,556	31·00	81,805	2,106,479	25·75	127,430	2,952,035	(b) 858	14,953	17·49
1900..	20,531	615,930	30·00	61,678	1,480,272	24·00	105,743	2,096,202	(b) 1,169	22,283	19·07

(a) Includes alumina, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground. (b) There was also imported in 1898, 1,205 short tons ($76,884) of alumina hydrate, or refined bauxite, and in 1899, 1,926 short tons ($119,202), and in 1900, 2,207 short tons ($148,332)

The statistics of the production of alum and aluminum sulphate given in the above table are computed from the consumption of bauxite and cryolite in the United States, and the production of aluminum, it being assumed that what is not used for aluminum is used for making the sulphates. The yield of both American and imported bauxite is well known, and consequently this is an accurate method of determining the production in so far as it is expressed in terms of crystallized alum. The division into crystallized alum and aluminum sulphate is estimated, and consequently is only approximate. However, since it is apt to be misleading to report the entire production as crystallized alum, of which really only a comparatively small amount is made, we began in 1897 to report our statistics of this industry in the present form. Any apparent discrepancy is thus accounted for. The production of alum shale in the United Kingdom in 1899 was 5,820 long tons (£728) against 13,617 tons (£1,702) in 1898.

Market Conditions.—New York prices of alum were $1·65@$1·75 per 100 lb. for lump, $1·85 ground and $2·50 powdered. Aluminum sulphate, owing to competition, was unsteady at $1·15 and $1·25 per 100 lb. for the commercial quality, and $1·50@$2 for the purest.

Natural Alum.—The Alum Co. at Bullahdelah, New South Wales, during 1899 shipped 921 tons of alunite (£2,763) to the United Alkali Co.'s works at Runcorn, near Liverpool, England.

AMMONIA AND AMMONIUM SULPHATE.

THE production of ammonia (reported as its equivalent sulphate salt) and ammonium sulphate by by-product coke oven plants in the United States during 1899 was 7,051 short tons. While statistics for 1900 are not available at this time, it is certain that the output will show a marked advance and may reach 10,000 tons. A new plant with 400 ovens at Everett, Mass., owned by the New England Gas and Coke Co., was in operation throughout the year, and the capacity of the plant at Ensley, Ala., was increased by 120 additional ovens. At the close of 1900 there were 2,181 ovens in existence or in the course of erection which were distributed as follows: (Semet-Solvay ovens) Syracuse, N. Y., 30; Dunbar, Pa., 50; Sharon, Pa., 25; Wheeling, W. Va., 120; Detroit, Mich., 30; Ensley, Ala., 240; total, 495; (Otto-Hoffman ovens) Otto, Pa., 120; Johnstown, Pa., 160; Lebanon, Pa., 232; Everett, Mass., 400; Buffalo, N. Y., 564; Camden, N. J., 100; Hamilton, Ohio, 50; total, 1,626; (Newton-Chambers ovens) Pocahontas, Va., 60. In this statement no account is made of the 30 Newton-Chambers ovens at Latrobe, Pa., erected in 1896, which have not been operated as by-product ovens, or of the three experimental Slocum ovens at Bolivar, Pa. The By-product Coke Co., with a capital of $6,000,000, has purchased the rights to operate in New York City under the Otto-Hoffman patents. Most of the by-product ovens are operated to produce coke as primary products, and the gas, tar and ammonia as by-products. The gas is largely used for fuel purposes, but the plants at Everett, Mass., Camden, N. J., and Hamilton, Ohio, were erected for the main purpose of supplying illuminating gas. Ammonia and ammonium sulphate are recovered also at some of the gas works in this country, the principal ones being located at Peoria, Ill., Dayton and Cleveland, Ohio, Indianapolis, Ind., Boston, Mass., and New York, N. Y. The Consolidated Gas Co. of New York, operating in New York City, is the largest producer.

The imports of ammonium sulphate into the United States for the past five years are given in the tables of imports and exports at the end of this volume.

According to the annual report of the Chief Inspector of Alkali works, etc., for the United Kingdom, the production of ammonium sulphate during 1899 amounted to 208,481 long tons, against 196,357 in 1898 and 198,280 in 1897,

an increase that more than counterbalances the slight decrease of 1898. Coke works and gas works furnished the main part of the yield and in the latter branch of the industry it is interesting to note the increased use of gas, particularly when it is borne in mind that the gas production throughout the United Kingdom has been more and more supplemented by admixture in various proportions of water gas made from coke and steam in which operation no ammonia is produced. The development of the coke manufacture and the collection of its by-products will result in an increased yield from this branch of industry; several additional plants were operated in 1900, and others were extended. Mr. Beilby estimates that if the 130,000,000 tons of coal now coked annually in bee-hive ovens were treated in recovery ovens, the world's production of ammonium sulphate would be increased 111,000 tons from this source. The method of recovery of ammonium sulphate in gas works has been fully treated by Hans A. Frasch in THE MINERAL INDUSTRY, Vol. VII., to which reference should be made. The production of ammonium sulphate in the United Kingdom for 1897, 1898, 1899 and 1900 is stated in the subjoined table:

PRODUCTION OF AMMONIUM SULPHATE IN THE UNITED KINGDOM. (IN TONS OF 2,240 lb.)

	1897.	1898.	1899.	1900. (*a*)		1897.	1898.	1899.	1900. (*a*)
Gas works	132,724	129,590	136,529	138,000	Coke works	10,624	11,568	15,209	15,000
Iron works	17,779	18,000	17,963	18,000					
Shale works	37,153	37,264	38,780	39,000	Total	198,280	196,357	208,481	*b*210,000

(*a*) Estimated. (*b*) Of this amount England furnished 134,000 tons, Scotland 73,000 tons, and Ireland 3,000 tons.

The world's production of ammonium sulphate is estimated at upward of 400,000 tons, representing a value of $24,000,000. In 1899, Germany produced 115,000 tons and France 35,000 tons. The main consumption of the product is in the manufacture of fertilizers. The Otto-Hoffman system is the one in most general use in Germany, there being 2,500 Otto ovens.

Markets.—In the American market ammonium sulphate gas liquor (25%), domestic, sold at $2·90 per 100 lb. f. o. b. works, Everett, Mass.; late in the year prices were $2·775 to $2·80. Foreign gas liquor ammonium sulphate sold at $2·95 to $3·055 per 100 lb. in January; late in the year at $2·75 to $2·825.

Average price per 100 lb. of gas liquor ammonium sulphate, basis 25%, in New York in 1899 and 1900, was as follows:

Year.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1899	$2·716	$2·662	$2·667	$2·810	$2·975	$3·337	$3·190	$3·111	$3·065	$2·975	$2·850	$2·895	$2·938
1900	2·925	2·956	3·081	2·981	2·887	2·840	2·725	2·825	2·755	2·750	2·775	2.775	2·856

In Liverpool, England, makers quoted gray, 24 to 25%, gas liquor ammonium sulphate at £11 7s. 6d. to £11 17s. 6d. in January, and about 5s. less at the close of the year.

Technology.—A new method of producing ammonium sulphate has been devised by Mr. Green, of the Preston Gas Works, England. The waste gases heat the incoming liquor by passage through tubes and the hot liquor then passing to

a divided flanged pipe containing a steam pipe connected with the steam boiler at both ends, one end returning the condensed water to the boiler. These pipes are of considerable length and have a slight rise from the outlet. At two points in the length of the divided flanged pipe are outlets for the removal of the ammonia gas to the saturator; the liquor with the fixed or combined ammonia is conducted to a small liming vessel with agitators to keep the lime in suspension. The saturators are of copper and receive continuous streams of mother liquor and acid. After several hours the salt collects in the saturator and is discharged from the bottom into a box from which the entrained mother liquor is drained. With the aid of three floating telescope siphons, measured quantities of ammonia liquor, lime liquor and acid are supplied with exactness to the apparatus. The process is continuous and is not patented.

With regard to the oxidation of ammonia by iron ore, as studied by Dr. Carrick Anderson and his coadjutors,* Dr. Grouven's researches also indicate the distinctive action of iron oxide on ammonia at high temperatures—a fact that should be carefully noted for the design of recovery plants where ammonia is subjected to high temperatures, as in coke ovens. Dr. Grouven suggests that if the destructive action of contact with the red hot brick work is in any way catalytic, the presence of iron oxide in the bricks may prove a factor of importance, also, that when oxygen is present with the evolved gas at a temperature too low for the direct oxidation of combustion, (140 to 150°C.) a reaction on ammonia may occur. In the opinion of at least one competent critic, iron works practice indicates that the amount of ammonia in the gases as they issue from the furnace top is substantially the same as when such coals are distilled in a gas retort; and therefore no considerable loss from reduction by iron ore can occur. It must be remembered that the greater part of the ammonia is evolved *pari passu* with the combined water of the coal and ore, and is protected by the large volume of water vapor, from interaction with the ore while being swept forward by the passage of the gases out of the zone of reaction into the upper part of the furnace where a low temperature prevails. Conversely, the cyanogen evolved in the hottest part of the furnace just above the tuyeres (where it may be removed) is not so protected and is almost wholly decomposed in its passage upward through the furnace. In a properly regulated blast furnace recovery plant, the proportion of ammonia not removed by the washers is very trifling in amount, but in comparison with gas works practice it has been pointed out that inevitable losses of gas (and ammonia) occur at the charging bell, in the removal of pitch and dust from foul gas mains, etc., amounting in all to at least 7·5%. Such losses have no counterpart in a gas works plant, so that comparisons as to the yield must be guided by the considerations above mentioned.

During the year the third edition of Dr. George Lunge's extensive work on Coal Tar and Ammonia has appeared and in it is given a detailed description of the manufacture of coal tar and other valuable by-products. The section on modern coke ovens for the recovery of tar and ammonia has been well discussed, and several methods for the treatment of blast furnace gases are described in detail.

* *Journal of the Society of Chemical Industry*, December, 1899 and January, 1900.

ANTIMONY.

THERE were no new developments of importance in this industry last year, the production and trade remaining in control of Mathison & Co., of New York, with works at Chelsea, Staten Island, who also control the Chapman Smelting Co., of San Francisco. The latter concern smelts ores from mines west of the Mississippi River and refines mattes imported from Japan.

PRODUCTION AND IMPORTS OF ANTIMONY IN THE UNITED STATES.

Year.	Production.				Imports.				
	Metal.		Ores.		Metal or Regulus.		Ores.		Total Value
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	
1896.....	1,226,000	$84,717	300,000	$4,750	3,583,300	$170,092	1,180,828	$21,392	$191,484
1897.....	1,500,000	107,250	1.000,000	16,000	1,146,696	46,955	5,502,132	167,373	214,328
1898.....	2,000,000	165,000	(a)	(a)	2,025,133	143,909	3,725,222	50,256	194,165
1899.....	b2,500,000	241,250	1,200,000	20,000	3,160,697	240,988	3,982,133	47,841	288,829
1900.....	b3,200,000	301,440			3,632,843	285,749	6,035,734	78,581	364,330

(a) There was an increase in the production, but complete statistics were not collected. (b) Estimated.

California.—The Wild Rose Antimony Co. made some shipments of ore to the Chapman smelter, averaging 49 to 50% antimony. The company is developing four claims near Ballarat in Southern California, which are said to show an 8-ft. vein with outcroppings traceable for nearly a mile. The property is favorably situated as to wood and water and will soon have good transportation facilities. During 1899 the mines near Mojave, Kern County, produced 150 tons of stibnite, which yielded 75 tons metal. The Chapman works pay $30 per ton for ore assaying 40 to 50% antimony, but refuse anything below 40%. No allowance is made for the gold content, as this metal does not occur in sufficient quantities to pay for its separation.

Nevada.—Deposits of antimony occur on the summits of the Toiyabe Mountains near the town of Austin, Lander County. Some development work has been done, and 200 tons of high-grade ore have been taken out and shipped. The principal ore body, it is said, averages from 1 to 3 ft. in width. Timber and water are at hand, while a good road leads from the mines to Clifton depot on the Nevada Central Railroad.

South Dakota.—The finding of auriferous antimony ore was reported at Silver City. Assays showed 42·5% antimony with some silver as well as gold.

WORLD'S PRODUCTION OF ANTIMONY ORE. (*a*) (IN METRIC TONS.)

Year.	Austria.		Borneo. (*b*)		France and Algeria.		Hungary.		Italy.		Japan. (*e*)	Mexico. (*f*)	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1895..	695	$26,688	657	$64,100	5,703	$75,367	1,240	$26,877	2,241	$40,254	1,061	600	$14,281
1896..	905	38,702	(*c*)		6,333	84,509	1,361	22,572	5,086	60,590	827	3,231	32,093
1897..	864	38,255	(*c*)		5,466	83,538	1,800	34,563	2,150	27,657	348	5,873	71,835
1898..	679	22,867	(*c*)		4,571	69,462	2,201	20,219	1,931	43,822	1,006	5,932	98,815
1899..	410	15,244	(*c*)		7,592	130,493	1,965	34,205	3,791	44,862	(*c*)	10,382	115,292

Year.	New South Wales.		New Zealand.		Portugal.		Queensland.		Spain.		Turkey. (*b*) (*d*)	United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1895....	486	$36,255	55	$7,430	753	$33,889	(*c*)		44	$700	1,322	982	$37,905
1896....	135	9,170	21	2,250	595	26,775	(*c*)		54	1,385	100	136	4,750
1897....	172	18,060	10	763	417	28,063	(*c*)		354	6,483	400	454	16,000
1898	84	4,580	*Nil.*	,	245	6,736	*Nil.*		130	2,149	(*g*)	(*g*)	
1899....	331	13,470	*Nil.*		59	2,123	41	$1,000	50	1,560	1,173	544	20,000

(*a*) The foreign statistics are derived from the official reports of the several governments; those for the United States were collected specially for THE MINERAL INDUSTRY. (*b*) Export figures. (*c*) Not yet reported. (*d*) Fiscal years. The Turkish statistics are of doubtful accuracy. (*e*) Mostly crude antimony. (*f*) Export figures, values in Mexican dollars. (*g*) Statistics not collected.

WORLD'S PRODUCTION OF ANTIMONY METAL. (*a*) (IN METRIC TONS.)

Year.	Austria.		France and Algeria.		Germany. (*d*)		Hungary. (*b*)		Italy.		Japan.	New South Wales.		United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons	Value.	Tons.	Value.	Tons.	Tons.	Value.	Tons.	Value.
1895.	296	$44 175	779	$98,734	989	$107,960	465	$57,507	423	$56,986	640	44	$6,460	422	$70.330
1896.	422	52,655	969	130,217	1,326	156,111	500	59,313	538	72,440	517	23	3,200	556	84,712
1897.	424	51,350	1,033	141,857	1,665	210,744	523	63,360	404	57,072	524	(*c*)		680	107,270
1898.	343	42,236	1,226	163,200	2.711	302,892	855	109,681	380	62,550	233	(*c*)		907	165,000
1899.	271	33,772	1,499	243,840	3.149	347,200	940	139.502	581	87,900	(*e*)	(*c*)	(*c*)	1,137	241,250

(*a*) From the official reports of the respective countries. (*b*) Crude antimony and regulus. (*c*) Not reported. (*d*) Includes manganese. (*e*) Statistics not yet available.

Australasia.—A body of antimony ore near Alexandra, Otago, has been prospected with encouraging results. Tests showed the ore to be of good quality with a high percentage of antimony, and a trial shipment was made to England.

Canada.—The deposit of antimony ore at the West Gore mine, Nova Scotia, consists of a 6-ft. vein, 20 in. of which is pay ore, comprising stibnite, kermesite, valentinite, galena and a small amount of gold contained in the calcite gangue. The vein cuts gray talcose slates which strike E. and W. and dip 45°. First grade ore assays from 50 to 80% antimony, the second grade yields a concentrate of about 54%. This mine was idle since 1892, but has recently been put in operation.

France.—Antimony ore is mined in Algeria, Corsica and in the south of France. Large ore bodies have lately been discovered in the Pyrenees. The total output in 1899 was 7,592 metric tons, valued at $130,493, an increase of about 3,000 tons over 1898.

Italy.—The only deposits worked at present are located in the provinces of Grosseto and Cagliara. There are some 15 mines, the entire output of which ranges from 2,000 to 4,000 tons per year. The ore is smelted at Rosia. The presence of small lenticular veins of stibnite in mica schist of the Val Soana, Turin, is reported.

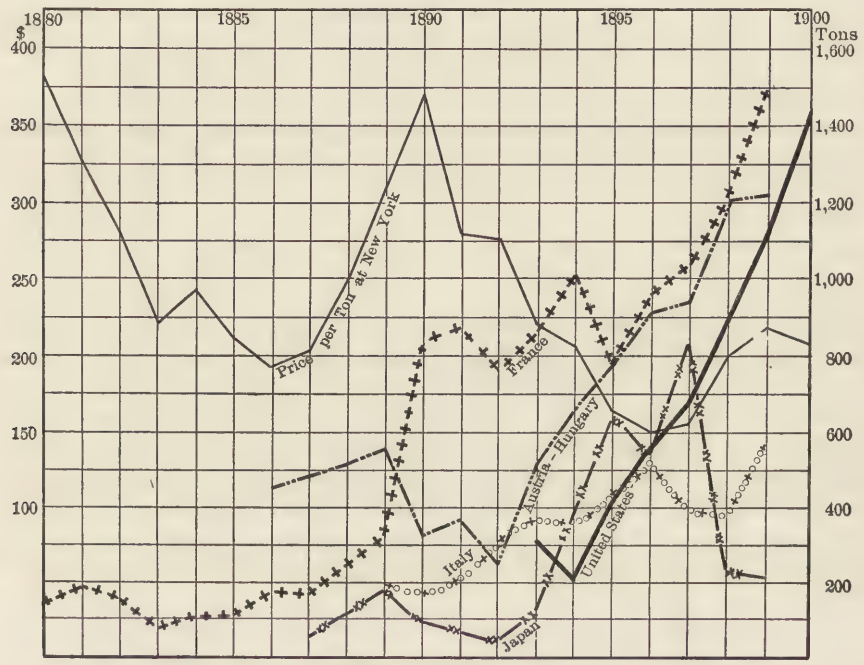
Servia.—This country possesses extensive ore deposits which were formerly very productive. Lately they have been taken over by a French company and

their exploitation resumed. The mines are located in the western part of Servia in the mountainous district of the Styra and Bosnia rivers, of which Kostainik is the commercial center. The ore (stibnite) forms veins, pockets and seams in slates and trachyte.

Turkey.—Several antimony mines are being worked at present, of which the most important are at Allkhur and near Aidin. In 1899 the exports from Smyrna and Salonica amounted to 1,173 tons, valued at $81,960.

The New York Antimony Market during 1900.

Notwithstanding the large increase in supplies from both domestic and foreign sources the market for antimony was firm throughout the year. The demand,



The World's Production of Antimony in Metric Tons.

no doubt, was increased somewhat by the higher prices ruling for antimonial lead, which, in certain cases, made it more profitable for manufacturers to buy the antimony and lead and prepare their own mixtures. Most of the foreign supplies of metal were drawn from England, but the imports from the Continent were of increased importance. Italian antimony came upon the market as a new brand and met with favor among the consumers.

Prices fluctuated but little. The year opened with Cookson's selling at 10·5 @11c., Hallet's at 9·75@9·875c., other brands at 9·75c. These figures were maintained until the spring, when supplies increased through heavy imports. The market then sold down about one-fourth of a cent for certain grades, at which price a good demand developed and the values were firm until the fall. Prices

then fell off again, and the year closed with Cookson's selling at 10c., Hallett's at 9·25c., other brands at 9@9·25c.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (IN CENTS PER POUND.)

Year.	Brand.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1896....	Cookson's	7·55	7·43	7·37	7·44	7·50	7·37	7·00	7·00	7·00	7·00	7·00	7·18	7·23
	Hallett's	7·10	6·90	6·87	6·81	6·75	6·75	6·75	6·50	6·50	6·50	6·46	6·68	6·71
	U. S. Star	7·25	7·09	7·00	7·00	7·00	6·91	6·75	6·75	6·75	6·75	6·75	6·93	6·91
	Japanese	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75	6·75
1897....	Cookson's	7·12	7·31	7·37	7·44	7·25	7·25	7·25	8·00	8·00	8·00	7·81	7·81	7·55
	Hallett's	6·80	6·90	7·06	7·00	7·00	7·00	7·00	7·28	7·37	7·50	7·40	7·40	7·14
	U. S. Star	6·80	7·00	7·06	7·22	7·05	6·78	6·87	7·28	7·37	7·50	7·40	7·50	7·15
	Japanese	6·75	6·80	6·75	7·00	6·75	6·78	6·87	7·15	7·25	7·25	7·15	7·18	6·91
1898....	Cookson's	8·00	8·00	8·25	8·37	9·20	9·65	9·75	9·75	9·75	9·70	9·25	9·25	9·08
	Hallett's	7·37	7·56	7·81	7·96	8·64	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·51
	U. S. Star	7·50	7·59	7·81	7·92	8·64	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·52
	Japanese	7·44	7·58	7·81	7·90	8·59	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·51
1899....	Cookson's	9·31	10·25	10·37	10·10	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10 50	10·37
	Hallett's	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·65	9·72	9·75	9·75	9·67
	U. S. Star	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·56	9·50	9·50	9·50	9·65
	Chapman's		9·62	9·75	9·80	10·00	10·00	10·00						
	Hungarian			9·75	9·80	10·00	10·00		9·75	9·56	9·50	9·50	9·50	
1900....	Cookson's	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·10	10·00	10·00	10·00	10·34
	Hallett's	9·75	9·75	9·75	9·75	9·69	9·62	9·53	9·50	9·30	9·25	9·25	9·25	9·53
	U. S. Star	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·30	9·25	9·25	9·25	9·42

PROGRESS IN THE METALLURGY OF ANTIMONY.

Electrolytic Deposition.—H. Ost and W. Klapproth* have investigated the electrolytic deposition of antimony and found that pure antimony can be easily precipitated from its salts by the use of a porous diaphragm. Where the metal is to be separated from tin, however, the E. M. F. employed must not exceed one volt. The cell used consisted of a platinum basin, a porous Pukall cell and a platinum disc anode. A solution of Schlippe's salt, Na_3SbS_4, containing 0·09859 g. Sb in 10 c.c. and one of pure Na_2S containing 195 g. per liter were used. The precipitation of antimony being the result of a secondary reaction, the antimony solution together with the sodium sulphide is placed in the cathode compartment while sodium sulphide alone is contained in the anode section. The best results were obtained with a current of 1 ampere at from 1 to 2 volts and a temperature of 70°C. operating for at least an hour.

Antimony in Alloys.—E. S. Sperry† has pointed out that in some cases the occurrence of cracks during the rolling of brass is due to the impurities present in the copper of the alloy. For a brass of 60% Cu and 40% Zn quantities of antimony varying from 0·01 to 0·65% were added and the alloys obtained were tested in a rolling mill. With alloys containing 0·02% Sb or more, the fracture of the rolled metal indicated its presence.

Analytical Methods.—Arthur Chippendale‡ aids the solution of antimony oxide ores by boiling in concentrated hydrochloric acid to which is occasionally added crystals of potassium iodide. When dissolved, the antimony may be determined by usual methods.

* *Zeitschrift für Angewandte Chemie*, 1900, p. 827.

† *Transactions of the American Institute of Mining Engineers*, August, 1900.

‡ *Engineering and Mining Journal*, May 12, 1900, p. 553.

ARSENIC.

THE world's supply of arsenic and arsenical compounds is derived almost entirely from England and Germany. A small quantity is produced in Spain from the quicksilver ores of Almaden, but it is used locally in the manufacture of colors. Turkey exports about 500 tons of orpiment annually from the mines of Allkhar, where it is associated with antimony; while deposits of realgar are worked in Persia. Italy, Austria, Japan, and Canada are also small producers, the output of Canada in 1900 being 606,000 lb., valued at $22,725.

Experiments have been resumed by the Puget Sound Reduction Co., of Everett, Wash., with a view of recovering arsenic from the Monte Cristo (Wash.) ores, and it is possible that this country will soon enter the list of producers. At present the United States depends entirely upon imports to supply its constantly increasing needs. The imports in 1900, including white and metallic arsenic and arsenic sulphides, amounted to 5,765,559 lb. ($265,500), against 9,040,871 lb. ($386,791) in 1899. The imports in previous years were: 1898, 8,686,681 lb. ($370,347); 1897, 7,242,004 lb. ($352,284); 1896, 5,813,387 lb. ($215,281); 1895, 6,984,273 lb. ($237,747); 1894, 7,063,442 lb. ($218,636).

THE WORLD'S PRODUCTION OF ARSENIC. (*a*) (IN METRIC TONS.)

Year.	Canada.		Germany.				Italy. (*d*)		Japan.	Spain. (*e*)		United Kingdom. (*f*)	
			Prussia.		Saxony. (*c*)								
	Tons.	Value	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.	Tons.	Value.
1895...	*Nil.*		1,788	$98,363	1,217	$108,826	100	$8,000	7	184	$18,390	4,875	$260,990
1896...	*Nil.*		1,750	130,529	882	90,626	320	24,400	6	271	27,100	3,674	227,415
1897...	*Nil.*		1,924	143.775	1,063	152,122	200	18,600	13	244	29,256	4,232	373,975
1898...	*Nil.*		1,624	121,818	1,053	131,710	215	15,700	7	111	13,320	4,241	268,935
1899...	52	$4,842	1,470	128,678	953	138,572	304	26.483	(*b*)			3,890	271,180

(*a*) From official reports of the respective countries. (*b*) Statistics not yet available. (*c*) Arsenious acid. (*d*) Metallic arsenic and arsenious acid. (*e*) Arsenic sulphide. (*f*) Arsenious acid.

The entire output of Canada was made by the Canadian Gold Fields, Ltd., at Deloro, Ont., in connection with its gold extraction plant. The ores are concentrated and treated by the bromo-cyanide process and after drying, pass through a revolving cylinder roaster. The fumes which are collected in a series of brick chambers are refined by re-roasting in a reverberatory furnace of special form and condensing in a second set of chambers. Bolting and packing are

accomplished in securely sealed rooms. The additions and alterations recently made have increased the output of the plant to 50 or 60 tons of white arsenic per month. A large roaster, refiner and galvanized iron condensers are among the improvements. The Atlas Arsenic Co., Ltd., is operating a 10-stamp mill on a tract known as "The Gatling five acres," 1 mile from Marmora Station on the Central Ontario Railway and intends to erect an arsenic plant in the near future. Small quantities of white arsenic of fair quality have been made in trial furnaces at the Toronto Smelting Co.'s works at Madoc. Nearly all the Canadian arsenic is marketed at New York.

In Saxony the prices for white arsenic meal and white piece arsenic ruled somewhat higher in 1899.

As to the methods employed at present in the smelting works of Freiberg, Dr. A. Schertel, of the Royal Academy of Mines, states: "The processes of arsenic recovery have not changed materially from the description given in the former volumes of THE MINERAL INDUSTRY, and the preparation of white arsenic is still carried out by subliming the flue-dust of the roasting furnaces upon the hearth of a reverberatory furnace, which is heated by means of producer gas prepared from coke. The method of preparing arsenic glass from nickel arsenide remains unchanged, while the greater part of red arsenic is likewise recovered by the old methods. There are, to be sure, a few improvements in this process, but the officials desire to keep the matter secret on account of the competition."

During the year 1900 a Royal Commission was appointed in England to investigate the subject of arsenical poisoning through impure food and drink. Considerable agitation was aroused in that country by an epidemic of sickness which was popularly attributed to the use of arsenicated sulphuric acid in the manufacture of beer.

Determination of Arsenic.—F. A. Gooch and Julia C. Morris* estimate arsenic acid iodometrically as follows: Sulphuric acid with a slight excess of potassium iodide is added to the soluble arsenates and the bulk of the liberated iodine expelled by boiling. The solution is then bleached by the addition of sulphurous acid and after neutralization with sodium hydrate and bicarbonate, the resultant arsenite is titrated with iodine solution in the usual way.

O. Ducru† estimates arsenic in a weak ammoniacal solution, rich in ammonia salts, precipitated with cobalt salts. The conditions necessary are the cobalt must be about one and one-half times the theoretical quantity, and the solution should be slightly ammoniacal. If it contains in the free state 1·5% of its volume of 20% ammonia, the conditions for the formation of mono-ammonic arsenate of cobalt are fulfilled. Practically about 3% should be taken. It is also necessary to charge the liquid with ammonium chlorohydrate, about 100 g. per liter, though in certain cases it is preferable to use acetate.

For the determination of arsenic in alloys, Hollard and Bertraux‡ propose the following method: 5 g. of the granulated metal are placed in the flask with 50 g. of ferric sulphate freed from all traces of nitrous fumes by evaporation

* *American Journal of Science*, August, 1900.

† *Comptes Rendus*, Nov. 26, 1900.

‡ *Bulletin Société Chimique*, Vol. XXIII., No. 8, 1900.

with an excess of sulphuric acid. Then 150 c.c. of pure hydrochloric acid are run in by means of the funnel and the tap turned off, after seeing that the oil-bath containing the U-tube is at 150 to 175°C.; the flask is then gently heated. The metal dissolves, and the arsenic distils over in the form of arsenious chloride; this chloride is collected in the test-jar, which already contains 50 c.c. of water. The operation is stopped when 35 c.c. of liquid have passed into the test-jar, which takes about half an hour. Under these conditions only the arsenic passes into the test-jar, the antimony remaining in the U-tube which contains glass beads, and prevents the passage of any projections which might leave the flask. The arsenious solution is then titrated with iodine. Besides its rapidity, this method has the advantage over other similar ones of being applicable in the presence of a considerable quantity of antimony, without requiring more than one distillation. It is not absolutely correct, however, when applied to the estimation of arsenic in metallic antimony, as a small amount of antimony passes over on distillation.

Thorn Smith* estimates arsenic in Paris green by treating it with a solution of sodium hydroxide which causes a precipitation of cuprous oxide in the presence of the arsenite. The precipitate is removed by filtration, and potassium iodide is added to the filtrate after acidifying with hydrochloric acid. The free iodine is then reduced by the cautious addition of sodium thiosulphate, and the arsenite determined by titration.

For determining the presence of free arsenic in insecticides, J. K. Haywood† describes a method as follows: 1 g. of sample is digested in a stoppered flask with 500 c.c. water for 10 days with occasional shaking, and after adding sodium bicarbonate the arsenious oxide in the filtrate is estimated by standard iodine solution. To determine the total arsenious oxide and copper, the sample is boiled with sodium hydrate, which precipitates the copper, leaving arsenious oxide in the filtrate. The copper is preferably determined by volumetric method based on the titration of iodine set free from potassium iodide in an acetic acid solution. The arsenious oxide also is determined iodometrically.

Market Conditions.—The market for Paris green was dull throughout the year. Dealers entered the season with stocks nearly sufficient to meet the demand, and the manufacturers were unable to dispose of a large share of their product. Pure Paris green was quoted at 14c. in New York at the opening of the year, and fluctuated between that figure and 12·5c. up to July. For the last six months prices were steady at 12·5@13c. per lb. White arsenic sold at 4·5@5c. per lb. and red arsenic from Germany at 7·25@8·25c., according to time of delivery.

* *Journal of the American Chemical Society*, September, 1899. † *Ibid.*, September, 1900.

ASBESTOS.

THE production of asbestos in the United States in 1900 was 1,100 short tons, valued at $16,500, against 912 tons ($13,860) in 1899. California made no output, the mine in Tulare County being closed down throughout the year. In Georgia, the Sall Mountain Co. continued operations in its mine of short fiber asbestos, which is used principally for insulating purposes, more particularly in the manufacture of asbestolith, a fire-proofing and flooring material. The discovery of a deposit of mineral similar to that found in the Sall Mountain mine was made near Clarkesville, Ga., and sufficient development work was done in the year to expose a large body of the rock.

PRODUCTION AND IMPORTS OF ASBESTOS IN THE UNITED STATES.

Year.	Production.				Imports.		
	Short Tons.	Metric Tons.	Value.	Value per Metric Ton.	Manufactured.	Unmanufactured.	Total.
1896.....	716	650	$12,670	$19·49	$15,654	$229,084	$244,738
1897.....	840	762	12 950	16·99	10.570	264,220	274,790
1898.....	885	803	13,425	16·72	12,899	287,636	300,535
1899.....	912	827	13,860	16·76	8,949	303,119	312,068
1900.....	1,100	998	16,500	16·54	24,155	331,796	355,951

Owing to the fact that a manufacturing concern in the United States gained control of the market, the prices for crude asbestos showed a marked advance in 1900. Notwithstanding this, there was a strong demand for all kinds of manufactured goods, and before the end of the year the available supplies of raw material became limited.

PRODUCTION OF ASBESTOS IN THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Canada.		Cape Colony.(*c*)		Italy.		Russia.		United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1896.....	11,113	$429,856	20	$1,160	42	$1,096	1,131	$6,800	650	$12,670
1897.....	27,617	445,368	47	490	106	5,240	1,274	7,666	762	12,950
1898.....	21,577	486.227	161	10,185	131	9,000	1,022	37,444	803	13,425
1899.....	22,938	483,299	(*b*)		81	7,264	(*d*)		827	13,860
1900.....	27,797	763,431	(*d*)		(*d*)		(*d*)		998	16,500

(*a*) From official reports of the respective countries. (*b*) Not stated in the reports. (*c*) Exports. (*d*) Statistics not yet available.

Australia.—Mining is carried on only intermittently, although the mineral is of widespread occurrence, being found in various parts of New South Wales,

Tasmania, Queensland and South Australia. In 1900, the Australasian Co. shipped a small quantity of asbestos from its mine near Beaconsfield, Tasmania, and a deposit of long fiber was discovered near King's Battery in the same colony.

Canada.—(J. T. Donald.)—The productive area of Quebec, which is the principal source of supply of asbestos and asbestic, is still limited to the district around Thetford and Black Lake on the Quebec Central Railway and to an isolated boss of serpentine near Danville on the Portland branch of the Grand Trunk Railway. The rocks are of Cambrian age. In the Laurentian formation to the north of the Ottawa River, about 20 miles east from Ottawa, there is also a deposit which yields limited quantities of a short, soft fiber asbestos that has special uses, it being remarkably free from iron and other objectionable matter. Until recently, Black Lake was considered inferior to Thetford as an asbestos area, but the workings in compact rock have yielded lately a fiber quite equal to the Thetford. The present condition of the asbestos industry is very healthy; prices are high while the demand is greater than the output, and there are no accumulations of stocks. The facts that no other productive district has yet been developed and that the principal Quebec mines show no diminution in output have given the Canadian industry great stability.

The best grades of asbestos, Nos. 1 and 2, are simply cobbed or freed from the enclosing rock by hand and marketed in the natural condition, while the lower grades, Nos. 3 and 4, being dressed or milled, are in the so-called "fiberized" state. The milling plant consists of rolls, Cyclone pulverizers and screens.

It is difficult to get a correct idea of the prices, as a great deal depends upon the grade—No. 1 grade of one company may be little superior to No. 2 of another producer. The Canadian Asbestos Co. quotes the following prices, which have been confirmed by other concerns: No. 1, $200 per short ton; No. 2, $137 per short ton; No. 3 (fiberized), $100 per short ton; No. 4 (fiberized), $75 per short ton; No. 5 (paper stock), $25 per short ton. In 1900 the output was about 19,000 short tons, giving employment to more than 1,000 people. The following companies were in operation at Thetford and Black Lake: Bell's Asbestos Co., King Bros., the Johnston Co., Beaver Asbestos Co. and the Canadian Asbestos Co. The Asbestos & Asbestic Co. worked the Danville mines; its output was less than in preceding years owing in part to the destruction of its milling plant by fire. This company devotes considerable attention to the production of asbestic, which is a by-product of asbestos mining. A large percentage of the serpentine, as it is taken out, is waste, the asbestos seams being too narrow to be worked for asbestos alone. This waste rock is crushed and can then be mixed with lime and used for wall plaster. It gives a light, flexible but strong plaster which does not crack or curl under the action of heat and is susceptible of a fine surface finish. About 12,000 tons of asbestic were marketed in 1900. The material is growing in favor both in America and Europe.

New Caledonia.—It is reported that long fiber asbestos of good quality has been discovered at Oubatche. The common occurrence of the mineral is too hard and short in fiber for commercial value.

Russia.—The Russian product comes from the Urals and Siberia and is said to be of good quality, but the supply is insufficient to meet home consumption.

ASPHALTUM.

ALL mineral bituminous products are treated under this heading, as in previous volumes of THE MINERAL INDUSTRY.

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1898.			1899.			1900.		
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Bituminous sandstone:									
California	a 46,836	a$137,575	$2·93	a 40,321	a $116,097	$2·70	a25,355	a$101,420	$4·00
Kentucky	2,700	8,700	3·22	1,783	7,132	4·00	8,922	37,472	4·20
Total	49,536	$146,275	$2·95	42,104	$123,229	$2·75	34,277	$138,892	$4·05
Asphaltic limestone:									
Utah	(c) 150	750	5·00	250	1,250	5·00	2,550	12,750	5·00
Indian Territory	13,949	69,745	5·00	10,128	53,172	5·25	1,360	4,080	3·00
Total	14,099	$70,495	$5·00	10,378	$54,422	$5·24	3,910	$16,830	$4·30
Asphaltum:									
California	a 25,690	a 482,175	18·77	a 15,060	a 308,130	20·46	d11,140	218,520	19·62
Grahamite:									
Utah	b 2,675	80,250	30·00	3,150	97,650	31·00	3,279	98,370	30·00

(a) Statistics of the California State Mineralogist. (b) Including 115 tons produced in Colorado. (c) Estimated. (d) Includes production in Indian Territory.

The National Asphalt Co. was incorporated in 1900 to take over the Barber Asphalt Paving Co., the Asphalt Co. of America, the Pennsylvania Asphalt Co., the Gilson Asphaltum Co., of St. Louis; the Gilsonite Roofing & Paving Co., the New Jersey Mexican Asphaltum Co., the Manhattan Trap Rock Co. and titles to three valuable asphalt deposits upon the east shore of Lake Maracaibo, in Venezuela, known as El Mene, Templador and Laguinillas. The authorized issue is $6,000,000 5% 50-year collateral gold certificates, and a capital stock of $22,000,000 divided into 200,000 $50 shares of 6% cumulative preferred stock and 240,000 $50 shares of common stock; the act taking effect January 1, 1901. This combination is said to control 95% of the supply companies handling the output of raw asphaltum, as well as a number of prominent asphalt paving companies.

California.—There was a marked decline in the output of asphaltum and bituminous sandstone in 1900, which was due to the decreased demand for these products at important centers of consumption, particularly San Francisco. The Alcatraz Asphalt Co., which is identified with the National Asphalt Co., continued to supply the greater part of asphalt for paving purposes. This company owns and controls all the deposits of bituminous rock on the Lisquoc ranch in northern Santa Barbara County, and has a large refinery at Alcatraz Landing

on the seacoast. For a description of the plant and methods employed for extracting the asphalt, the reader is referred to THE MINERAL INDUSTRY, Vol. VIII. The Globe Asphalt Co., which operates at Obispo, Santa Barbara County, made some shipments of asphaltum in 1900, the larger part going to Chicago and Buffalo. Its product is a mixture of rock asphalt and asphaltic residue from the refining of the heavy petroleum. The Kern River oils are especially rich in asphaltic products. Among the other asphalt companies there was very little activity last year, a number of them suspending operations entirely. The output of bituminous rock was made by several concerns, the most important being the City Street Improvement Co. of San Francisco, and the San Luis Obispo Rock Co. with the allied interests of the Consolidated Bituminous Rock Co. This product is consumed on the Pacific Coast, where owing to the simple processes of treatment and the low rates of transportation by water it is a successful competitor of asphalt. The occurrence and genesis of Californian asphalt is described by A. S. Cooper in THE MINERAL INDUSTRY, Vol. VIII., p. 53, to which reference may be made.

Indian Territory.—Both asphaltic limestone and bituminous sandstone are mined near Dougherty, the deposits being very extensive. A portion of the product is shipped in crude form to adjacent points, where it is used directly as paving material, but the larger part is converted at the mines into mastic. By the incorporation of the Gilsonite Roofing and Paving Co. into the National Asphalt Co., the output is now controlled by the trust. In 1900 the shipments of rock amounted to 1,360 tons, and of mastic 2,140 tons, a falling off from the returns of the previous year.

Kentucky.—The production of asphaltum, which is really a bituminized sandstone, amounted to 8,992 short tons in 1900. The rock is quarried by ordinary methods and subsequently crushed or pulverized. For use as pavement it is passed through steam heated drums where it attains a temperature of from 250 to 300°F., the time of passage being 15 minutes. It is then hauled by wagon to where desired and laid in the same manner as ordinary asphaltum. The pavements made from this product are very durable and satisfactory.

Utah.—The asphaltic limestone and grahamite deposits in the eastern part of the State were exploited as usual. The output of asphaltic limestone varies from year to year, but shows little tendency to increase, as the home market is limited and the prices offered for the material do not warrant the paying of long distance freight rates. On the other hand there is a steadily growing demand for grahamite which is shipped to various parts of the country to be manufactured into varnishes, lacquers, paints, etc. The production of grahamite in 1900 was 3,279 tons, the greater portion being derived from this State.

West Virginia.—There has been no reported production of grahamite from the deposits in Ritchie County, which were fully described in THE MINERAL INDUSTRY, Vol. VIII.

ASPHALTUM IN FOREIGN COUNTRIES.

Argentina.—Samples of asphalt from Jujuy were shipped to the United States to be refined and prepared by methods similar to those in use for the Trinidad

product. The results, however, were unsatisfactory, as the material was impure, and the location of the deposit is such as to make it practically impossible to market the product.

THE WORLD'S PRODUCTION OF ASPHALTUM AND ASPHALTIC ROCK. (*a*) (IN METRIC TONS.)

	Austria.	France.	Germany	Hungary.	Italy.	Russia.	Spain.	Trinidad. (*e*)	United States.		Venezu'la (Bermudez). (*e*)
	Asph. Rock.	Asph. Limestone. (*b*)	Asphaltum.	Asphaltum.	Asph. Rock.	Asphalt. (*c*)	Asph. Rock.		Asphaltum. (*f*)	Asphaltic Rock. (*g*)	
1895..	404	39,891	59,563	2,284	46,713	18,783	790	92,862	23,156	42,976	3,073
1896..	390	34,394	61,552	2,740	45,456	22,192	1,117	100,400	18,519	39,531	6,197
1897..	300	30,946	61,645	3,057	55,339	22,222	1,656	133,310	24,854	45,233	11,528
1898..	643	36,000	67,649	3,125	93,750	(*d*)	2,354	108,792	23,306	57,728	*Nil.*
1899..	2,635	39,000	74,770	3,060	81,987	(*d*)	2,542	144,340	13,662	50,061	12,014

(*a*) From the official reports of the respective countries, except where noted to the contrary. The production of grahamite in the United States and Manjak in Barbadoes is not included (*b*) France produces a large amount of bituminous shales, used for distilling oil, which is not included in these statistics. (*c*) The statistics for 1895 and 1896 are official returns furnished by the Department of Mines, St. Petersburg, to C. Le Neve Foster for his Blue Book on Colonial and Foreign Statistics for 1897. (*d*) Not yet reported. (*e*) Exports (crude equivalent) reported by The New Trinidad Lake Asphalt Co. (*f*) Statistics reported by the California State Mineralogist, the entire American product being derived from California. (*g*) Statistics based on direct reports from the producers, including asphaltic limestone and sandstone.

NOTE.—There is a considerable production of asphaltic stone in Switzerland of which no account is taken in the above table, the Swiss Government not publishing any mineral statistics.

Cuba.—It is reported that asphalt of a superior quality is being produced in the Province of Santa Clara, but details of production are not available. The deposits referred to in THE MINERAL INDUSTRY, Vols. VII. and VIII., have not been exploited, probably on account of the inferior quality of the material and the difficulty in transportation.

France.—Bituminous schist is mined extensively in the departments of Saône-et-Loire and Allier. The entire output in 1899, amounting to 209,000 tons, was distilled for oil. The output of asphaltic limestone in all 39,000 tons was used as paving material and came from the departments of Ain, Gard, Puy-de-Dôme and Haute Savoie.

Italy.—The total production of asphaltic and bituminous rock during 1899 amounted to 81,987 tons. Ragusa, a town in the southwestern portion of Sicily, is becoming an important asphaltum mining center. Four large companies are operating there, the greater part of the output being carted to Mazzarilli for shipment; the remainder being carried by railway to Syracuse. The shipments during 1899 from these ports were respectively 29,410 tons and 21,650 tons. Much of the product is shipped to Hamburg; some 5,700 tons found a market in New York.

Mexico.—Jas. R. Johnson, of Austin, Tex., has obtained a 20-year lease on deposits of asphalt in the State of Tamaulipas and a thorough examination of the property is under way. The mineral is found in the fluid state at from 10 to 20 ft. below the surface and the few wells that have been sunk indicate the existence of a large deposit. The field is 60 miles from the Monterey & Mexican Gulf Railroad. The principal expense of production will be the wagon transportation to the railroad. A contract between the City of Mexico and the Barber Asphalt Paving Co. for paving 75 of the principal streets was approved April 26, 1900. Three classes of material are specified at prices respectively of $9, $10 and $11 (Mexican currency) per square meter—the streets to be kept in repair by the company for 10 years. One-half of the contract amount is to be

paid to the company upon the acceptance of the work by the Commissioner of Public Works, and the balance within 10 years, in yearly installments.

Russia.—Deposits of asphaltic limestone containing 7 to 15% bitumen are found near Syzran and are worked by two companies. Asphaltum occurs in the provinces of Kazan and Samara, while bituminous sandstone is mined on the islands Tscheleken and Naphthadagh and is of common occurrence in the Caucasus. Asphaltic dolomite occurs at Kertsch. In the preparation of mastic the rock is treated in kettles with boiling water until temperature of the content has been raised to 60 or 80°C., and this product is then mixed with pulverized limestone at a temperature of 200°C. Asphalt products are also prepared from goudron.

Trinidad and Tobago.—The exports of asphalt from the Island of Trinidad are given in the following table, for which we are indebted to the courtesy of Mr. Ira Atkinson, treasurer of the new Trinidad Lake Asphalt Co., Ltd. Seven-eights of the asphalt exported is dug from Pitch Lake, which is leased to a company for a term, of which 29 years have yet to run. In view of the fact that at Bermudez, in Venezuela, a similar lake ten times its size, and containing asphalt purer in the proportion of 97 to 56, is already being worked, Trinidad can no longer claim to command the asphalt market. The demand for asphalt is, however, growing and there are greater difficulties in shipping it from Bermudez than from Trinidad. Pitch in a liquid form mixed with a bituminous oil is also to be found in the south of Trinidad. The commercial value of this deposit has, however, not yet been satisfactorily tested.

EXPORTS OF LAND ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1896....	11,943	71	12,049	842	1,988	3,824				15,873
1897....	19,243	*Nil.*	19,243	293	700	1,343	415	178	682	21,268
1898....	18,160	*Nil.*	18,160	700	258	1,087	404	312	872	20,119
1899....	25,613	345	26,130	275	280	695		100	150	26,975
1900....	34,796	(*b*)	34,796	251	(*b*)	251	197	(*b*)	197	35,244

EXPORTS OF PITCH-LAKE ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Dried.	Total Equivalent in Crude.	Crude.	Épuré and Dried.	Total Equivalent in Crude.	Crude.	Épuré and Dried.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1896....	60,637		60,637	8,320	8,052	20,391		1,300	1,918	82,946
1897....	71,969	1,769	74,407	14,629	13,510	34,856		500	680	109,943
1898....	46,089	1,692	48,424	15,703	13,228	35,537	693	1,646	2,999	86,960
1899....	70,111	480	70,777	21,337	13,749	41,956		1,699	2,359	115,092
1900....	67,758	3,180	70,938	23,386	16,114	47,352	1,422	2 420	4,453	122,743

(*a*) The exports prior to 1896 will be found in THE MINERAL INDUSTRY, Vol. VII. (*b*) Included in the shipments of crude.

Venezuela.—The asphalt beds are in the Department of Sucre, formerly the Department of Bermudez, 100 miles to the westward of the Port of Spain, on the Island of Trinidad, and on the west bank of the Guanoco, a small creek emptying into the San Juan River, is the settlement of Guanoco, the headquarters

of the New York & Bermudez Co. The Guanoco & La Brea Railway connects the settlement of Guanoco with the asphalt lake, 6 miles to the north, where there are a few native huts and a large, modern asphalt refinery and shipping station. The lake is 2 miles long and 1 mile wide, and is indented slightly by a narrow ridge of dry land. The lake asphalt is very nearly pure, cargoes having been shipped to New York which contained only from 2 to 4% of impurities. To refine this asphalt it is simply necessary to heat it until the water is evaporated, for there is no scum, dirt or foreign matter in it. The average Venezuelan will dig and load into a dump car from 2·5 to 3 tons of asphalt in an 8-hour working day, and it is recorded that some of the more hardy ones have loaded as much as 8 tons in 10 hours. They receive 50c. per day for their labor, and one ration averaging in cost from 16 to 19c. per day. The laborers at the Bermudez plant are usually one-half native Venezuelans, the other half being West Indian negroes, with an occasional sprinkling of coolies from Trinidad who have completed their seven years' labor contracts and do not care to return to the East Indies. There are rarely ever more than five or six American citizens at one time on the company's premises, all of them being superior officers charged with administrative affairs. At present the New York & Bermudez Co. has two chartered steamers under foreign flags to bring up asphalt to New York. Troubles arose concerning the La Sucre asphalt beds, near the end of the year 1900. President Castro granted a part of the asphalt lake to the Warner-Quinlan, or La Felicidad Co., against the remonstrance of the New York & Bermudez Co., which claimed the entire lake under its concession. The matter was finally referred to the Venezuelan Court, where it is still under advisement.

Technology and Uses.

Failures in Asphalt Pavements.—A. W. Dow* divides the disintegration of asphalt pavements into three classes: 1. Cracking. 2. Rolling or waving. 3. In spots. 1. A crack is formed by the contraction of the asphalt surface through cold, beginning generally at a manhole or similar iron opening. Sometimes it occurs at a joint between an old and a new pavement and sometimes between portions laid in successive days, though this does not result when the work is properly done. Cracks appear sooner and increase more rapidly in streets with little or no traffic than in well traveled thoroughfares, the action of which appears to knead the material together and thus prevent the formation of cracks. The proper admixture of materials to prevent cracks depends upon climate and exposure, a north and south street exposed to a wide range of temperature, being the most difficult to handle. The sand should be sharp, well graded from coarse to fine, with the latter in large amount, and saturated with asphalt cement, which should be as soft as possible up to the point of marking too deeply during the hottest weather. 2. Disintegration from rolling or waving is due to soft wearing surface or to defective bond between the binder and the base or bearing surface. The traffic under these conditions pushes the surface into waves and crowds it toward the gutter, a defect most notable in streets with heavy traffic. To avoid this the concrete base should not be too smooth, but rough enough to

* *Report of the Commissioner of the District of Columbia*, 1900.

prevent the crowding of the surface and binder mixtures when too soft. When proper care is taken to secure a perfect union between the parts, disintegration should not occur from this cause. 3. Disintegration in spots may be due to several causes, as: non-homogeneous mixtures, irregularity of wear, deficiency of asphalt cement, all noticeable in cold weather, when isolated spots become brittle and are easily ground away. Sometimes oil from the binder is absorbed by the surface mixture, making it soft and more susceptible to the action of water. Experiments demonstrate that asphalt is softened by the absorption of illuminating gas, and as a result of gas leakage from mains, the pavement may become covered with fine cracks and begin to crowd. Another source of disintegration is the rotting action of water which, in oozing from the soil, affects the under portion of the surface mixture so that subsequently the upper portion yields to the crowding of traffic. The foregoing shows that beyond defective material there are many causes of disintegration of asphalt pavements, nearly all of which are preventable. It is claimed that better results can be obtained with poor material carefully used than with best material used carelessly.

Action of Water.—The action of water on asphalt has been carefully studied by G. C. Whipple and D. D. Jackson.* The experiments extended over a period of two years, and the conditions of actual practice were closely approximated. With asphalt linings of water reservoirs, the material at the water line is alternately wet and dry and is further exposed to the erosive action of moving pieces of ice; below the water line it is in continual contact with water, with increased pressure as the bottom is approached. Seventeen samples of asphalt (excluding rock asphalts) were tested, and the investigation was conducted along the following lines: 1. The samples were placed in jars of water and any subsequent change in the analysis of the water was noted, thus ascertaining the nature of the soluble constituents of the asphalts. 2. Samples were immersed in water under various conditions and any change in weight noted. 3. Changes in physical condition due to the action of water were carefully observed. Both surface and distilled water were used in the experiments, and great differences in the action of different varieties were shown. The observed results are of material value for the selection of proper asphalt for reservoir linings. The results of the action of water on the samples of asphalt tested show that in some cases the color is changed from black to brown and the asphalt becomes soft and punky with superficial cracks and pits—notably in the Trinidad asphalt and to a less degree in the Bermudez variety. Alcatraz asphalt acted in a similar manner, although in some cases to a very slight extent. The hard Cuban asphalt was unaffected, as was also Assyrian asphalt, with the exception of No. 5 grade. According to Richardson the molecular structure of the asphalt is a very important consideration. Water is absorbed physically and it was observed that those waters containing the smallest amount of mineral matter acted the most strongly on the asphalts. Sea water had but little action upon them, while distilled water showed the greatest effect. Oxygen determinations in cubic centimeters per liter gave: Distilled water 7·1, sea water 4·8, brine 0·9. The action of water on asphalt therefore is due mainly to the oxygen dissolved in the water. A test of the action on Trinidad asphalt of water that had been freed from oxygen by

* *Engineering News*, March 17, 1900.

boiling and the jar tightly sealed to prevent absorption of oxygen from the air showed a very slight effect. These tests substantiate the opinion that the water acts merely as a carrier of dissolved oxygen and does not give up the oxygen of its composition. Reference is made to the reservoirs at Denver, Colo., one of which was lined with Trinidad and one with California asphalt in 1891. The linings became affected to a marked degree by water action.

Chemical Analysis.—J. Kovács and S. Sötét* devised the following method for the distinction of natural from petroleum pitch. This is of value, as pitches of inferior quality are frequently substituted for natural asphalt in paving material. The sample is extracted with carbon disulphide and the filtered extract heated to 110°C. in a water bath which expels all moisture. One gram of the residue is redissolved in 2·5 g. carbon disulphide and a similar solution prepared for comparison from a natural asphalt of known purity. Six samples were tested: Trinidad bitumen, Dalmatian, bituminous limestone, Tataros (Hungary) bitumen, petroleum pitch, coal-tar pitch, and an asphalt paving mixture of unknown composition. One c.c. of solution prepared as described above was mixed with 2·5 c.c. of turpentine oil. The coal-tar pitch gave a light brown solution and a brown deposit while the solutions of the other samples remained dark in color and gave no precipitate; 10 c.c. of absolute alcohol were added to these solutions and black precipitates were formed with the exception of the solution from the coal-tar, which was of a brownish color. The precipitates, dried at 95°C., were of different physical characteristics; that from the coal-tar was light brown and pulverulent; that from the bitumens, sticky, lustrous and black; while the other two were earthy and black. On treatment with 5 c.c. of absolute alcohol 1 g. original solution from coal-tar pitch gave a brown precipitate, while the solutions from the other samples gave precipitates of black color. The superior properties of natural asphalt bitumens explain their superiority for paving material as compared with petroleum pitch, which consists largely of earthy matters cemented by resins and oils which soon lose their cohesive properties under the influence of sun and frost.

S. F. Peckham† gives the results of his investigation of parianite or Trinidad pitch and while many facts of importance as to its solvents, etc., are stated, the composition of the pitch itself still remains unsettled. The discussion of this paper brought forth the various analytical methods that have been applied to this material.

Refining Asphaltum.—Arthur F. L. Bell patented an apparatus‡ for extracting and refining asphaltic material. It consists of a stationary casing containing a revolving cylinder which is heated by means of an enclosed hollow core. Jacob Philippi patented§ a machine for separating rock asphalt, having an upright casing with suitable hopper to supply the rock used, perforated steam buckets to remove the waste material and a stationary trough to carry the melted asphaltum outside of the casing. An exhaustive account of the modern methods of refining asphalt is given by Hans A. Frasch in THE MINERAL INDUSTRY, Vol. VII., pp. 75-86.

* *Chemical Review, Fett. und Harz Ind.* 7 (1), 8.

† *Journal of the Franklin Institute*, March, 1900.

‡ United States Patent No. 655,430, Aug. 7, 1900.

§ United States Patent No. 655,416, Aug. 7, 1900.

BARYTES.

THE production of barytes in the United States in 1900 amounted to 41,466 short tons, which was derived from Missouri, North Carolina, Tennessee and Virginia as in the previous year. Several new mines were opened up in Cocke County, Tenn., and near the close of the year a deposit of barytes was opened near Bessemer City, N. C.

The mined barytes in lump form is usually hand sorted for the removal of adhering gangue, and the selected material coarsely crushed, boiled with dilute acid for the removal of iron oxide stains, washed, dried and finely ground. The fine material is usually sorted by floating in water and graded according to fineness, the finer product being of better grade and higher price. The most common impurities are quartz and limestone from the gangue of the ore and iron stains which require removal as the product should be perfectly free from color. The greater part of the production is used in the manufacture of paint by mixing with white lead or zinc white and, while it is usually considered as an adulterant, it is an improvement for some purposes especially if discoloration from acid fumes, smoke or sea-water is to be prevented. A portion of the product is used for making enamels in porcelain and pottery manufacture, and a small amount is consumed in pyrotechny and for the manufacture of chemical reagents.

PRODUCTION, IMPORTS, AND CONSUMPTION OF BARYTES IN THE UNITED STATES.

(In tons of 2,000 lb.)

Year	Production.			Imports.			Consumption.	
	Quantity.	Value Per Ton.	Value.	Quantity.	Value Per Ton.	Value.	Quantity.	Value.
1896.....	21,900	$4·00	$87,600	3,333	$7·39	$24,619	25,233	$112,219
1897.....	26,430	4·00	105,720	2,018	7·14	14,401	28,448	120,121
1898.....	28,247	4·00	112,988	1,914	5·93	11,356	30,161	124,344
1899.....	32,636	4·20	137,071	4,312	6·59	28,407	36,948	165,478
1900.....	41,466	3·90	161,717	5,625	5·77	32,461	47,091	194.178

PRODUCTION OF BARYTES IN THE PRINCIPAL COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Belgium.	Canada.	France.	Germany.				United Kingdom.	United States.
				Baden.	Bavaria.	Prussia. (*c*)	Saxony.		
1895....	32,750	(*b*)	2,530	*Nil.*	3,587	29,263	284	21,509	20,255
1896....	25,000	131	2,791	130	3,397	38,438	574	24,117	21,900
1897....	23,000	518	3,209	400	3,365	36,394	218	23,087	26,430
1898....	21,700	971	2,763	1,100	4,339	48,082	478	21,514	28,247
1899....	25,900	1,207	4,058	2,430	6,214	52,920	216	25,059	29,607

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) Not reported. (*c*) Output of the mining districts of Clausthal and Bonn.

Market.—The consumption of barytes in 1900 showed an improvement and prices at New York ruled steady. Crude No. 1 domestic was quoted at $9@$10 per short ton; No. 2, $8@8·25; No. 3, $7·75@$8; American floated, $14·50 @20, according to quantity and quality. German floated barytes was quoted at $14·50@$17·50. The demand for *blanc fixe* (artificial barium sulphate) was very satisfactory during the year and prices at New York ruled at 1c. per pound.

Lithophone.—The United States Board of General Appraisers has decided that lithophone, also commercially known as white sulphide of zinc, is dutiable at 1·75c. per lb., and is not to be included under the division entitled "paint or pigment containing zinc but not containing lead."

Tennessee.—The barytes deposits occur in beds of clay at many points throughout the entire valley of the Tennessee River in the eastern part of the State, but the largest deposits under development are in the neighborhood of Sweetwater, Philadelphia and Loudon. According to R. H. Shiflett, the Hiawassee Mining Co. of Knoxville, has opened a number of new barytes mines in Cocke County, along the line of the Southern Railway and is extensively developing the properties. This company has secured control of the Lonsdale mill property at Knoxville, and crushers, washers and dryers to grind and refine the product have been installed; heretofore the crude ore has been shipped to the mills at Lynchburg, Va., and Philadelphia, Pa. But little has been done at the mines of Traynor & Hardwick of Cleveland, Tenn., while those near Sweetwater, Monroe County, were worked during the summer; the ore being hauled and loaded at Sweetwater where at the end of the year from 4,000 to 5,000 tons were stocked. In Green County the ore occurs in the Chilhowie conglomerates in stratified veins, which are continuous along the strike and increase with depth, varying from 2 to 5 ft. of easily mined crystallized ore. Near Myers Station there are six parallel veins crossed by sharp ridges which permit tunneling and stoping at a low cost. The production of barytes in Tennessee during 1900 was 16,605 short tons against 14,000 in 1899.

The Manufacture of Barium Peroxide.—This industry began in Germany in 1880 and oxygenized water was manufactured in France in 1887. The peroxide then obtained was of 82% strength, while at present a product containing 92% is in the market. Witherite, the natural barium carbonate occurring in Scotland and elsewhere, is chiefly used for the manufacture of the peroxide. The mineral is dissolved in nitric acid and the nitrate calcined. A portion of the nitrous oxides formerly wasted is now recovered and the barium sulphate resulting from the decomposition of the peroxide is also utilized by conversion into sulphide. It is possible to use barite, the natural barium sulphate, which is of more common occurrence than witherite, but its conversion into nitrate is too expensive for commercial purposes. The present annual production of oxygenized water amounts to nearly 3,000 tons, of which about one-third is from three chemical works in France. The transport of domestic barium peroxide in France must be made in iron casks.

BISMUTH.

THERE has been no report of production of metallic bismuth in the United States during 1900, although the Ballard mine and other properties on Breece Hill, Leadville, Colo., shipped about 220 tons of bismuth ore to Johnson, Matthey & Co., Ltd., England, for treatment. The ore contained an average tenor of 9% Bi and some gold, for which the purchaser paid. The world's supply of metallic bismuth is controlled by the combined interests of Johnson, Matthey & Co., Ltd., and the Saxon Government, who regulate absolutely the production and prices of the metal and its ores. The supplies of the metal are stated to be greatly in excess of the demand, and this superfluity is assigned as the reason for the necessity of such mutual arrangements as will enable the price to be maintained at a figure remunerative to mine owners. The schedule of prices for ore is based on the market price of the metal and with the latter at $1·25 a pound the following prices were paid on delivery at the smelting works, all deductions for treatment having been made: 10% ore, $150 per ton; 15% ore, $250; 20% ore, $350; 30% ore, $550; 40% ore, $750; 50% ore, $1,000. The wholesale price of bismuth during 1900 f. o. b. at works ranged from $1·60 per lb. in January to $2·25 per lb. in December. The Colorado sampling works offered to buy ore at the following rates: 8 to 10% ore, $10 per unit; 10 to 12% ore, $11 per unit; 12% or over, $11·50 per unit. According to the report of the Colorado Bureau of Mines, the gross bismuth value of ore extracted from the Leadville district last year was $26,500, or $15 per unit. Some of the ore carried as high as 9·5 oz. gold, and 7·5 oz. silver per ton, for which the producers received full value less deductions for treatment charges. All this ore was purchased by the Leadville Sampler at Leadville, the State Ore Sampling Works at Denver, or was shipped direct by producer to Johnson, Matthey & Co., Ltd.

Various minerals carrying bismuth are found in Colorado, the most important being the carbonate, which occurs in Lake, Larimer, Boulder and Chaffee counties; native bismuth, in Summit, Jefferson, Boulder and Larimer counties; tellurate and telluride, in Boulder and Ouray counties; sulphide, in Clear Creek, Larimer, Summit, Jefferson, Boulder, San Juan and Ouray counties; sulphobismuthite, in Park, Custer, Ouray, Hinsdale, Clear Creek, La Plata, Boulder, San Juan and Lake counties.

The importation of bismuth into the United States in 1900 was 180,433 lb., valued at $246,597, against 176,668 lb., valued at $208,197, in 1899. A small amount of medicinal preparations containing bismuth was also imported.

During the past year there has been nothing published worthy of record either in the new occurrences of bismuth ores or in their mining and metallurgical treatment. The ores have been fully described in the early volumes of THE MINERAL INDUSTRY, and the metallurgical treatment has been given in detail in Vols. V. and VIII., especially the latter. The European smelters continue to obtain their ores from Saxony, Bohemia, Bolivia and New South Wales. By far the greater part of the quantity produced in recent years in New South Wales has been derived from the Jingera Mineral Proprietary Co., operating chiefly in the Pampula district. The native bismuth occurs in a granitic formation associated with molybdenite, gold, arsenopyrite and tin. During 1899 ore to the value of $450 was raised from the Old Nanima mine in the Yass Division. The total quantity of ore exported from New South Wales in 1899 contained 15·5 tons of bismuth and was valued at $16,775, a slight decrease in amount and value from 1898. Promising indications of good bismuth ore have been reported from the Nymagee district and in Delunga, Bingara Division. The largest mass of native bismuth yet discovered in the State weighed 30 lb. and was obtained from the Kingsgate mine, which is now inoperative.

United States patent rights* have been granted to John Ranald for his method† of extracting bismuth from his ores by means of ferric chloride, as described in THE MINERAL INDUSTRY, Vol. VIII., p. 57.

D. Balachowsky‡ has devised a method for the electrolytic determination of bismuth by which a coherent, weighable deposit of bismuth is obtained from a nitrate or sulphate solution (but not the chloride). The essential conditions for success are, feeble acidity, absence of chlorine, bromine or iodine in any large quantity, weak current and rough electrodes.

G. Lunge§ gives the analysis of crude and refined bismuth as follows:

ANALYSIS OF CRUDE AND REFINED BISMUTH.

Components.	Australia.		Bohemia.	Bolivia.		Peru.	Saxony.							
Bismuth	94·103	96·2	99·32	99·053	99·069	93·372	99·77	99·390	99·830	99·791	99·745	99·922	99·849	99·982
Antimony	2·621	0·8		0·559		4·570								
Arsenic	0·290	Tr.						0·255			0·011	0·025	0·024	Tr.
Copper	1·944	0·5	Tr.	0·258	0·156	2·058	0·08	0·090	0·040	0·027	0·019	0·016	0·019	0·032
Lead		2·1	0·30						Tr.	0·084	0·108		0·049	0·065
Iron		0·4	Tr.				Tr.		0·026	0·017	Tr.	Tr.	Tr.	Tr.
Sulphur	0·430						0·10			Tr.	0·042			
Silver			0·38	0·083	0·621		0·05	0·188	0·075	0·070	0·066		0·047	
Gold					Tr.									
Tellurium					0·140									

* United States Patent No. 657,030, Aug. 28, 1900.

† English Patent No. 10,022, July 30, 1899.

‡ *Comptes Rendus*, 131, p. 179.

§ *Chemisch-technische Untersuchungsmethoden*, 1900.

BORAX.

THERE was an increase in the production of borax in 1900. The greater part of the output was derived from the colemanite deposits in California, the marsh deposits of California and Nevada contributing smaller amounts. No new borate deposits have been discovered during the year, and as heretofore the Pacific Coast Borax Co. has furnished the greater part of the raw material and finished product.

The Pacific Coast Borax Co. is now successfully operating its borate-concentrating plant at Marion on the line of the railroad from Daggett, Cal., to its colemanite mines. The low-grade ores, which were formerly rejected, are roasted in a Holthoff-Wethey furnace, with two hearths, and of a capacity of nearly 100 tons of raw ore per day. Six oil-burners furnish the heat, and the finely-broken ore is carried forward on the hearths by rabbles. Colemanite which is a crystallized calcium borate, generally with admixed impurities, disintegrates when mildly heated, the fine particles flying off in every direction, until each lump is reduced to a fine white powder. The product is bolted, and the purified flour sacked for shipment to the company's factory at Bayonne, N. J. The removed waste, locally known as "dry-bone," is often nearly equal in weight to the flour secured. Any pandermite ore, which is a rich borate, that may be present, is unaffected by the heat, and follows the waste. The flour, when boiled with soda forms borax and is more amenable to treatment than the raw material.

The newly-discovered colemanite deposits in Ventura County, Cal., 70 miles south of Bakersfield, have been operated continuously during the past year. Considerable development work has been done and the output increased. As the croppings of this deposit extend for 8 miles over a mountainous country, its full exploitation will naturally be a matter of many years. The ore is sent to the boric acid works of the Stauffer Chemical Co. of San Francisco, and to the borax factory of Thomas Thorkildsens Co., Chicago. The low-grade borate muds near Daggett, Cal., are now being worked by two companies, and a third is about to enter the field. The Western Mineral Co. has a perfected plant and treats the cold, unground mud with sulphuric acid, made locally. The liberated boric acid is washed from the mud, and the clear, settled liquors evaporated by solar heat. The resulting concentrate is shipped to Bayonne, N. J., for manufacture into borax or commercial boric acid. The output is gradually increasing. The Columbia Mining and Chemical Co. has constructed a plant at Daggett. The mud is ground by a Chile mill and the borates released by treatment with sulphurous acid, generated as required and applied to the mud slimes at a boiling

heat. The mass is then passed through filter presses and the filtered liquor evaporated to secure the concentrate. Eastern pottery manufacturers are developing a borate mud deposit in the hills near Marion, and have a chemist employed in devising a cheap process for working the material. Although these extensive deposits of low-grade borate clays are undoubtedly destined to play an important part in the borax supply of the future, the development of methods of extracting the boric acid, is slow and expensive, and it is not probable that their product will become a factor in the market at least for some years to come.

The Borax Consolidated, Ltd., the international borax combination, owning property in the United States, England, France and South America, reports a very favorable business for the fiscal year ending September 30, 1900. The company is capitalized at £1,400,000 ($7,000,000), of which £800,000 is preferred stock carrying 5·5% cumulative dividends, and £600,000 ordinary, both having a par value of £10. Of the £1,000,000 ($5,000,000) authorized in 4·5% mortgage debenture stock there has been issued since September 30, 1900, a total of £100,000, leaving £900,000 ($4,500,000) upon which interest is paid. The profit during the fiscal year 1899-1900 amounted to $1,363,705, an increase of $30,000 over that of the previous year. Since their incorporation in 1898 the profits have borne all expense of examination and development of reserve properties and have provided $137,500 for depreciation; $500,000 for reserve and $52,215 for debenture sinking fund; a total of $689,715. The mines and deposits of calcium borate worked have given excellent results, showing large reserves of material producible at a satisfactory cost. The demand for borax, boric acid and the other products of the company has continued highly satisfactory.

IMPORTS OF BORATES, ETC., INTO THE UNITED STATES.

	1899.			1900.		
	Metric Tons.	Lbs.	Value.	Metric Tons.	Lbs.	Value.
Borax	23·23	51,221	$3,508	125·15	273,706	$9,937
Borates of lime or soda (crude borate of soda and refined borate of soda)	19·13	42,165	2,979	26·44	58,294	5,306
Boric acid	263·99	582,002	20,560	214·67	473,251	17,436

The production of crude borax in 1900 was 24,235 short tons and of refined borax 1,602 tons. The value of crude borax in 1900 is taken nominally at $25 per short ton.

THE WORLD'S PRODUCTION OF BORATES, ETC. (*a*) (IN METRIC TONS.)

Year.	United States. Calcium Borate.	Chile. Calcium Borate. (*b*)	India. Borax. (*b*)	Germany. Boracite.	Italy. Boric Acid, Crude.	Peru. Calcium Borate. (*b*)	Turkey. Pandermite (*b*) (*c*)
1895	(*d*) 6,126	4,532	400	150	2,633	4,000	9,081
1896	12,310	7,486	340	184	2,616	1,179	12,626
1897	17,600	3,168	280	198	2,704	11,850	11,375
1898	13,911	7,034	184	230	2,650	7,178	(*e*)
1899	21,834	11,951	(*h*)	183	2,674	7,638	(*e*)

(*a*) From official reports of the respective countries except the United States. (*b*) Exports. (*c*) Fiscal years. (*d*) Product of refined borax. The manufacture of boric acid was begun in the United States in 1896, in which year there was a production of 621,000 lb. There are no statistics for subsequent years. (*e*) Statistics not yet available. (*h*) Not reported

Argentina.—A syndicate has been formed in Brussels with a capital of $2,000,000 to exploit the borax deposits in Jujuy and Salta; the product will be exported to Europe. Up to January 1, 1900, 120 tons of borate had been marketed. A sample from the mines gave boric acid 40·65%, CaO 13·55%, Na_2O 6·1%, NaCl 5%, H_2O 33·9, sand 0·9%. The cost of production and transport from the mines to Buenos Ayres is estimated at £5 4s. 2d. per ton, in sacks and the cost from Buenos Ayres to a port in the United Kingdom at from 20s. to 22s.

Chile.—The borax fields of Chilcaya near Arica in the northern section of the State, are operated by foreigners and, although 114 miles from the coast, the richness of the material is said to warrant the high cost of transportation. The deposits near Tocopilla are being developed and it has been proposed to open up the Maricunga deposits near Caldera.

Peru.—The exploitation of the calcium borate deposits in Peru is assuming considerable importance. In 1899 the output was 7,638 tons. The Salinas Valley, about 75 km. north of Arequipa, contains the principal deposits.

Progress in the Technology of Borax.

C. C. Moore has patented* a process for the production of boric acid and other products. Powdered crude calcium borate is suspended in water and is heated to 70°C., while chlorine is passed in; the gas is quickly absorbed, liberating boric acid and forming calcium chloride and chlorate. Most of the boric acid crystallizes out on cooling to a low temperature and is purified by recrystallization. The mother liquor is re-used until the alkali salts have accumulated sufficiently for convenient separation. It is suggested to use this process in connection with an electrolytic process producing both sodium hydrate and chlorine, in which case both products may be utilized.

Ledermarkt† states that the use of borax in tanning is advantageous, as it cleanses and accelerates the softening process when wool and furs are treated and prevents the hair from falling out. It should be used, however, only in the initial stages of treatment.

Analytical Methods.—According to C. Montemartini,‡ of all the methods proposed for the determination of boric acid, the one of Gootch only gives exact results. This method is based on the liberation of boric acid by nitric or acetic acid, changing it by methylic ether which is absorbed in a weighed quantity of lime and dried, calcined and re-weighed. From the increased weight due to the combination with the boric acid, the amount present is determined. Rosenblatt's method of determination has been rejected. It is similar to that of Thadeef, which is very complicated and difficult, and which gives results inferior to Gootch's method.

Stock§ draws attention to the liability of error from the presence of carbon dioxide in reagents used for the volumetric determination of boric acid, and suggests that all reagents should be boiled to expel the gas and the titration should be made with standard sodium hydrate which has been previously treated with barium chloride.

* English Patent No. 20,384, Oct. 11, 1899.
† *Chemiker Zeitung* (Repertorium), July 28, 1900.
‡ *Gazz. Chim. Ital.*, 1900, p. 344.
§ *Comptes Rendus*, CXXX., 516.

BROMINE.

THE production of bromine in the United States, including the proportionate amount of bromine contained in potassium bromide, increased during 1900 from 433,003 lb. to 521,444 lb. The price, however, decreased from 29 to 27c. The production of bromine in the world is still controlled by the associated American producers and by the Leopoldshall-Stassfurt convention, which has several years longer to run.

PRODUCTION OF BROMINE IN THE UNITED STATES.

Year.	Michigan.	Ohio.	Pennsylvania.	West Virginia.	Total.	Metric Tons.	Value.	
							Total.	Per Pound.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.			
1896.....	42,000	212,850	154,600	149,835	559,285	249	$143,074	26c.
1897.....	(a) 147,256	124,972	116,967	97,954	487,149	221	136,402	28c.
1898.....	(a) 141,232	106,860	119,998	118,888	486,978	221	136,354	28c.
1899.....	(a) 138,272	82,368	111,150	101,213	433,003	196	125,571	29c.
1900.....	(a) 210,400	91,182	105,592	114,270	521,444	237	140,790	27c.

(a) Including the bromine equivalent of the product recovered as potassium bromide.

THE PRODUCTION OF BROMINE IN MICHIGAN.

BY A. C. LANE.

THE bromine industry began in Michigan about 20 years ago and the history of its early development as described by Dr. S. S. Garrigues* is briefly summarized as follows: In 1880 Dr. Dickey, of Allegheny City, Pa., investigated the saline wastes of Bay City and Saginaw, Mich., with a view to the manufacture of bromine from them. While engaged in this work, several salt wells were put down in Midland County, about 20 miles west of Saginaw valley. The specific gravity of the brines being about 1·2273, the presence of magnesium bromide was strongly suspected and a subsequent analysis by Mr. Ayres, of the University of Michigan, gave the following results:

* *Proceedings of the Michigan State Pharmaceutical Association*, Vol. III., p. 139, 1885.

Components.	Brine from Midland County, from a Depth of 1,300 ft.		Bittern left after the Crystallization of Salt from the Brine.	
	3*a*	3*b*	4*a*	4*b*
	%	%	%	%
Sodium chloride	14·8984	14·7599	5·6754	6·0801
Calcium chloride	8·6666	8·8760	14·3574	14·5859
Magnesium chloride	2·4665	2·4109	3·9263	3·4019
Magnesium bromide	0·8771	0·8771	4·8356	4·8356
Ferrous carbonate	0·1144	0·0954		
Calcium sulphate	0·0199	0·0220	0·0160	0·0160
Water	69·5250	69·5250	63·3941	63·3941
Total	96·5679	96·5663	92·2048	92·3136
Specific gravity (evidently at 20° C.)		1·2273	1·2557	
Total residue, per cent		30·4750	30·6059	
Bromine in grams, per liter		0·936	5·280	
Chlorine " "		20·165	19·548	

The brine (Nos. 3*a* and 3*b*) was from the well of Harris Bros., at Midland, Midland County, 20 miles north of East Saginaw, on the Flint & Pere Marquette Railroad. The well was 1,300 ft. deep and the brine flowed at a rate of 30 gal. per minute. The bittern (Nos. 4*a* and 4*b*) was the mother liquor remaining after the crystallization of the salt from the brine Nos. 3*a* and 3*b*. Although the duplicate analysis agreed very closely, Mr. Ayres remarked that it was difficult to understand why so small a quantity of magnesium chloride existed in the bittern when compared with the amount in the original brine. He estimated the bromine by treatment of a given quantity with excess of chlorine during the evaporation to dryness; from this a total of silver chloride was obtained and by comparing the ratio of it with the weight of the mixed silver chloride and bromide from the original brine, the percentage of bromine was determined. As a result of this investigation a bromine manufactory was established at Midland, which was equipped with two stills of a total capacity of 200 lb. per day.

Since 1881 its manufacture has been conducted at Midland by several concerns, principally Larkin & Patrick and the Midland Chemical Co., the latter of which was recently absorbed by the Dow Chemical Co.

It is noteworthy that the percentage of bromine in the analysis of the Midland brine is quite high, being nearly 1 g. per liter, while in the resultant bittern it is from three to four times as great from the removal of the salt which forms three-quarters to five-sixths of the solids in the brine. Another fact worthy of attention is that the proportion of magnesium chloride in the brine and in the bittern appears to be relatively diminished. This may be of importance, for the presence of magnesium salts in the brine renders it very difficult to effect a complete separation of the bromine from the chlorine.

The general method of bromine manufacture consists in decomposing the bittern from the salt manufacture by chlorine water, which may be introduced separately or may be made by the addition of manganese dioxide and hydrochloric acid to the solution. The bromine is more or less completely expelled from its combinations by the chlorine and becomes dissolved in water. It is stated that sulphuric acid and pyrolusite, or potassium chlorate, is sometimes used for the oxidation and removal of bromine from its compounds. Generally the bromine is obtained by the distillation of the solution, but in the Dow process it is collected by blowing an air current through the solution and conducting

the gas through a tower containing quicklime, which absorbs the bromine and forms calcium bromide. It is marketed in this form, or else is transformed into the corresponding potassium salt. A high-grade limestone is necessary and should contain at least 98% $CaCO_3$. The most deleterious impurities are silica and iron. Limestone of this high grade is found at the Sibley quarry, Trenton, Mich., near Alpena, Mich., and in certain localities in Indiana.

The source of the bromine brine of Midland is in the Marshall sandstone, which occurs at its greatest recorded depth. At St. Louis it is equally deep and bromine was manufactured there for a few years, which included 1884. At Alma, 3 miles from St. Louis, there is a well in the Marshall sandstone which is quite brominiferous. It was carried down to the Devonian limestone, however, and the water from the lower stratum contained only 15·4026 grains NaBr per gallon, while the mixed water now put on the market, called the "Alma-Bromo," contains from 84·9091 to 80·8238 grains NaBr per gallon. The Red Cross Mineral Co.'s water well at Big Rapids also strikes the Marshall at 1,300 ft., and in spite of the fact that some water from the higher levels is included 67 grains of Br (or NaBr) per gallon, is found. Beside the crude water, these companies are putting various medical preparations on the market, in which bromine is doubtless an important constituent.

Other wells in the Marshall sandstone contain bromine in smaller amounts, but the attempts made to save it at East Tawas and at other places were of no commercial importance. At least 1,000 lb. of bromine per annum, however, are placed on the market in various medicinal preparations of mineral water.

The Devonian limestone mineral waters, and the brines of the Salina stage of the Silurian, have been exploited at many localities. The most important being Mt. Clemens,* (0·122); Ypsilanti, (0·267); Port Huron, Benton Harbor, (0·725); St. Clair (0·980). They always contain some bromine, but are not so strong for a given depth as in the Marshall sandstone. On the west shore at Muskegon (2·346), and especially in a well 2,500 ft. deep at Manistee (11·19) which passed through the Salina into the Niagara, also in a well 1,920 ft. deep at Harbor Beach (22·5), are concentrations found that resemble the brines of Midland (8·771). It is, however, only natural that in and near the Salina, where so much salt has been removed in rock salt beds, a concentration should be found of the more soluble potassium and bromine salts in the residual brines, and it is quite probable that the building of proper casing in a number of the wells cited above would result in the yield of better percentages of bromine and potash.

*The numbers after names of the towns refer to parts per thousand of bromides in characteristic brines of the town as given in analyses quoted from *Lower Michigan Mineral Waters*, A. C. Lane, Bulletin No. 31, 1899, U. S. G. S.

CALCIUM CARBIDE AND ACETYLENE.*

By L. K. Böhm.

History of the Invention.—Edmond Davy while producing the metal potassium in 1836 obtained as a by-product a residue of dark color containing potassium carbon oxide, which upon the addition of water generated acetylene.† Woehler,‡ in 1862, and Travers§ later produced calcium carbide by chemical methods. Electrical smelting entered the field in 1885, when Cowles obtained several United States patents‖ for the reduction of metallic aluminum and its valuable alloys by electric smelting.

Scientifically considered, the process of smelting ores electrically for the purpose of obtaining metals and metal alloys is a reduction, as from a chemical compound—the ore—there is produced an elementary substance—the metal. Therefore the process is an analytical one. But in the process of manufacturing calcium carbide, the action is quite different, for from a chemical compound, —the lime—and an elementary substance—the carbon—there is produced a new chemical compound—calcium carbide—and therefore this process is a synthetical one. From the above it is clear that all processes tending to produce metals by electric smelting do not bear on the invention of calcium carbide and ought not to be considered. Furthermore, electric smelting was begun in the United States and abroad for the purpose of producing metallic aluminum, which belongs to the chemical group of earthy metals, while calcium carbide contains the metal calcium which belongs to the chemical group of earth-alkali metals. Inventions made in the two different groups cannot be classed together, either in science or at the Patent Office.

The early patents granted by the United States for the production of calcium carbide are arranged in their chronological order as follows: (1) Thomas L. Willson, June 18, 1895, No. 541,137; application January 16, 1895. (2) Thomas L. Willson, June 18, 1895, No. 541,138; application March 4, 1895. (3) Thomas L. Willson, October 22, 1895 (reissue of 541,137), No. 11,511, and (4) William C. Clark, December 17, 1895, No. 551,461. (5) L. K. Böhm, December 24, 1895, No. 552,026; application November 5, 1891. Among the

* Special reference should be made to the article on "Calcium Carbide and Acetylene" in The Mineral Industry, Vol. VI., pp. 65–88, 1897, for information which this present contribution supplements.—Editor of The Mineral Industry.

† *Ann. Chem. Pharm.*, Vol. XXIII., p. 144.

‡ *Ibid.*, Vol. CXXXIV., p. 220.

§ *Proceedings of the Chemical Society*, CXVIII., p. 15.

‖ United States Patent No. 324,658, Aug. 18, 1885.

patents granted by foreign countries for the production of calcium carbide that of L. M. Bullier, of Paris, German Patent No. 77,168, class 12, February 20, 1894, is one of the earliest recorded. My patent is thus apparently the earliest filed and its description will be of interest. The claim is for calcium carbide obtained from lime and carbon by means of strong electric currents, and the process is described as "mixing together carbon and the oxides of the earth-alkali metals and thereafter effecting a chemical combination of the carbon and the metal by the action of an electric current;" also "a new article of manufacture—a compound consisting of a homogeneous mass of carbon and calcium forming the carbide of calcium."

Progress of the Industry during 1900.

The production of calcium carbide has gradually increased during the past few years. In 1899 there were 93 factories working or under construction, as reported in The Mineral Industry, Vol. VIII., p. 70, and in 1900 further progress was made in the production of carbide and in illumination by acetylene gas, both in the United States and Europe.

The international meeting of the calcium carbide manufacturers at Berlin on November 9, 1900, for the purpose of forming a syndicate proved unsuccessful, but a syndicate of German, Swiss, Austrian, Swedish and Norwegian carbide manufacturers was formed in Frankfort on November 30, and combined in establishing price schedules and a mode of controlling the sale of their products. The Deutsche Gold und Silberscheide-Anstalt, of Frankfort (which has branches in the United States and other countries), was appointed the sole agent for the sale of the syndicate's products. It is expected that by this combination the acetylene industry will be considerably strengthened. The members have adopted measures to avoid the fluctuating and ruinously low rates which, owing to heretofore existing sharp competition, have made the manufacture of their products unprofitable. The chief aim of the union is to raise the sale prices and keep the market steady.

United States.—In the United States calcium carbide is manufactured by the Union Carbide Co., at Niagara Falls, N. Y. The reason why this company is the sole producer of carbide is that the manufacture is strongly patented in the United States and the Union Carbide Co. owns the controlling patents of Böhm and Willson. In some European countries calcium carbide is not patented; for instance, in Germany the Bullier patent has been annulled by the Imperial High Court at Leipzig, and therefore anybody can manufacture it.

W. P. Martin, the general manager of the Union Carbide Co., states* that their new works at Sault Ste. Marie, Mich., are still in course of construction. The capacity of the works at Niagara Falls is 25,000 H.P., and all apparatus necessary for the utilization of that amount of power is installed. The works at Sault Ste. Marie, when completed, will have the same capacity as the Niagara Falls works. The Union Carbide Co. does not announce actual figures of production, but each year has shown a very large percentage of increase over the one previous.

* Private communication.

No radical improvements have been made in the method of manufacture during 1900, but the process has been refined in every direction, resulting in an almost uniform quality and a considerable reduction in the cost of manufacturing. In the United States carbide is sold at present in carload lots at $68 per ton; the retail price is $3·75 per 100 lb. f. o. b. Many of the most important distributing points in the country are east of the Mississippi River. The business as a whole is in a very satisfactory condition and the outlook is good. New generators are coming out on the market in large numbers and it is observed that recently not only better machines are being designed and placed for sale, but the class of manufactures has improved and the tendency is for very reliable and well established manufacturing concerns to take up the acetylene apparatus business. The company guarantees each pound of carbide to produce 5 cu. ft. of gas. As the real facts about calcium carbide are becoming understood by city councils, fire departments and insurance companies, the conditions for storage in cities have become more reasonable. Records of accidents with acetylene are kept by a number of apparatus builders, and it is my understanding that while a number of minor accidents have occurred there have been no fatalities, and in no case have the insurance companies been called upon to pay a fire loss resulting from the use of acetylene.

The Union Carbide Co. exports carbide and reports an increase in exportation. As far as can be learned a large part of this carbide goes to South America. It is still difficult to obtain reasonable rates for transportation of carbide by ship except to some few countries where the large volume of business has led to a better understanding of the nature of this product by transportation companies. Railroad freight rates in the United States are very reasonable, this product taking practically the same rate per 100 lb. as iron nails in kegs. Although no data can be obtained regarding the total output of carbide at Niagara Falls, it is generally accepted that about 10,000 H.P. out of 25,000 are utilized at present for the production of carbide, which will give in round numbers about 10,000 tons.

During the year 1900 over 250 patents have been issued by the Patent Office in Washington for carbide processes, acetylene lamps, burners, and principally acetylene gas generators.

Although the use of liquid acetylene or gas generating therefrom is still absolutely prohibited, the rules for the installation and use of acetylene gas generators as prescribed by the National Board of Fire Underwriters, are now less strict than formerly.

The *Acetylene Gas Journal,* of Chicago, Ill., recently compiled a list of towns in the United States in which public acetylene gas lighting has been recently installed. This interesting list is as follows: *Connecticut:* Bridgefield, Fairfield, Lakeville, Litchfield, New Milford, Salisbury and South Port. *Indiana:* Dana, Wabash and West Lafayette. *Iowa:* Adair, New Hartford, Preston and Salix. *Kentucky:* Dixon. *Michigan:* Manchester and Whitmore Lake. *Minnesota:* Hallock. *New Jersey:* Medford. *New York:* Milbrook and Union Springs. *Ohio:* Castalia. *Pennsylvania:* Bear Lake, Belleville, Montrose and

Wilkes Barre. *Texas:* Comstock. *Virginia:* Beaufort, Luray and Manchester. *Wisconsin:* Cambridge, Milton and Milton Junction.

A. Lipschutz* reports that the Great Northern Railway has at Hamline, Ramsey County, Minn., a freight transfer house lighted by acetylene. It consists of a warehouse of about 800 ft. long, with platforms on both sides, and offices at one end of the structure. There are about 100 acetylene burners of which 26 are in the office, the rest being arranged in three rows, one in the center of the freight house and one on each platform. The generator is installed in a small building about 20 ft. distant, which also serves as a dining room for the men. The office lights burn all night, while the other lights are needed for about four hours daily in the winter. The generator is a 100-lb. carbide machine and is charged every other day. The cost per lamp hour (22 c.p.) varies from 0·55 to 0·65c., according to the amount of gas used. This includes attendance, depreciation and renewals. The light furnished by the acetylene plant has reduced the cost per ton of freight handled, and no other system of lighting could be installed at that place which would rival it in economy. There are now a number of passenger stations and freight depots equipped with acetylene plants in operation and several others are under construction. They range from 20 to 60 lights each and in no case has an acetylene plant been decided upon except where its smaller operating cost, its independence of rented sources of light and its fine illuminating qualities, have shown it to be superior to other systems of lighting. Lipschutz states also that the commercial carbide as furnished to consumers in the United States is of greater purity than the European product. This may be due to purer raw materials.

The American Illuminating Shell Co., of Baltimore, Md., proposes the use of shells to light up large areas of ocean in life-saving work or to obtain the range of the vessel of an enemy. The shell consists of a hollow cylinder made of steel tubing and is charged with calcium carbide, which, coming into contact with water, generates acetylene. The end of the shell remains above water and the burners at this end are lighted by an electric device that is contained in the shell. The light produced is said to be 1,000 c.p. and cannot be extinguished by water. The shell is to be shot from a gun to a distance of 2 miles and floats with one quarter of its length above water.

Argentina.—A 3,000-H.P. factory for the production of calcium carbide has been erected at Cordoba by a London firm. It covers 5 hectares of ground and is 2 km. from the city limits. The power is derived from Casa Bamba, in the Cordoba Mountains, and is conveyed to Cordoba by cables. The supervision of the works is under the French engineer, Eugene de Boismenu. The location is considered an ideal one from the near presence of calcite deposits and abundant wood for charcoal.

Austria-Hungary.—Among the papers read at the International Congress of Applied Chemistry, held at Paris in 1900, was one by Mr. Gin, which gives interesting details as to the development of the carbide industry in Austria-Hungary, where the abundance of waterfalls has created a large number of plants. Seven large plants are in operation, using about 24,000 H.P., and others

* *Journal of the Association of Engineering Societies*, June, 1900.

are projected which will bring the total up to nearly 80,000 H.P. The *Imperial Industrial Journal,* December, 1900, reports that the largest of these works, from the point of view of capacity, is that of Iajce, which has been erected by the Bosnian Electric Co. and utilizes the large falls of the river Pliva. The river widens to a lake which discharges into a lower lake in a series of cascades. The dam has been placed a short distance below the mouth of the upper lake, where the water is taken off in a canal about 2 miles long; the canal passes through 15 tunnels of 12×15 ft. sections, which end in a large reservoir near the station. From this point the water is brought to the turbines by iron conduits of 5-ft. diameter. The capacity of the hydraulic plant is about 9,500 H.P. Eight turbines are installed in the station, of 1,000 H.P. each, connected to Schuckert dynamos. The electric furnaces for this plant have been installed by the last named company. The plant at Paternion is of much smaller capacity, but represents many points of interest. It has been installed by the Venetian Electro-Chemical Society and is located on the bank of the river Kreuznerbach. The lime is furnished by limestone quarries which are found in the neighborhood. A 200-ft. head of water is obtained from a waterfall in this stream; the water is brought by canals and conduits to the turbines at the station, 1,600 ft. from the fall. Here are installed three turbines, of 400 H.P. each, connected directly to a triphase alternator, working at 350 revolutions per minute. The grinding machines can pulverize 8,000 lb. of lime and 5,000 lb. of coke per day. This material is transported to a scale and thence by a converter to a screw mixing-tank; from here it falls to the doors of the electric furnaces by a series of conduits. The mechanical operations are carried out by two electric motors. Nine double electric furnaces are used, with space for three others to be installed later; the furnaces have a capacity of 125 H.P. each.

The Meran works is one of the most important. It is operated by the Gin and Leleux process, and utilizes the water power of the Etsche, one of the confluents of the river Adige. The fall has a height of about 280 ft. The canal is less than a mile long; it passes in a tunnel for a part of the way, and then two metallic conduits, 6 ft. in diameter, bring the water to the turbines; there are five of these, of the Garry pattern, with horizontal shaft. To these are coupled five alternators of 1,200 H.P. each. Of these, two are used for the carbide plant, to which the current is transmitted by two cables in subway and overhead line; they furnish 2,000 H.P. A deposit of very pure crystalline marble is found near the works. It is carried by an aërial wire-rope conveyor to the calcining furnace. The lime and coke are elevated by a bucket conveyor to the grinders, passing thence to the mixer and, finally, by a conveyor to the furnaces. The last have a capacity of 260 kilowatts each, and are disposed in a battery in a large room 35×130 ft. These furnaces are claimed to give an output of more than 11 lb. of crystallized carbide per kilowatt per day.

Among the plants to be shortly erected is that of Petrozeny. The fall of the Szill River here situated belongs to the Acetylene Co., of Vienna. It is about 75 ft. high at a maximum and a mean of 4,800 H.P. may be obtained. Another projected plant is that of Almissa, on the Cetina River. This large fall belongs

to a syndicate, which includes Ganz & Co., of Budapest, the Belgium Aluminum Syndicate and others. The fall is to be obtained by a derivation from the Cetina, using for the purpose a tunnel 5 miles in length, and in this way 50,000 H.P. can be utilized. Another fall on the same river is to be utilized by Descovics & Gin, who have obtained the concession. A head of water of nearly 300 ft. is assured, which will give 6,000 H.P. A central station is to be established below the fall and the energy is to be transmitted by the high-tension system at 12,000 volts to the port of Almissa, where the carbide works will be located.

France.—France possesses quite a number of carbide works, which utilize 20,505 out of 50,300 available H.P. During 1900 five new works were partly or completely constructed. A new company has been formed for raising sunken vessels by generating acetylene gas from carbide below the water. G. L. Bourgerel* describes the use of acetylene and air enriched with oxygen as a source of high temperature. Acetylene is burned in a glass blower's blow pipe with the usual compressed air, and oxygen is introduced into the air supply by means of a branch pipe. By suitably arranging the proportions of the gases, a flame is produced, which is but slightly luminous and in combustion is complete, either powerfully oxidizing or quite neutral, as desired. In this way a convenient and cheap source of intense heat is obtained that is comparable with the electric arc and capable of melting platinum in a few seconds. This flame is free from the reducing carburetting properties of the electric arc.

Germany.—Especial progress has been made in Germany according to Dr. Frederick Rose.† Knappich, of Augsburg, estimates the number of acetylene installations at about 8,000. These include small apparatus as well as gas works for the lighting of small towns. It is used for the lighting of towns, factories, public and private buildings, hospitals, barracks, castles, churches, country seats and public squares. Several mines are lighted by acetylene, using portable lamps that burn from 8 to 10 hours. It is extensively used for portable outdoor lighting, for photographic purposes, in boring tunnels and in picture galleries. In Alsace the dyeing and printing establishments have adopted it, largely because the colors may be distinguished by acetylene light at night as well as in the day time. It is well adapted for search lights because the apparatus is easily transported and the experiments carried out on the river Elba in presence of officials of the German Lloyd and the Hamburg Observatory proved its usefulness in lighthouses and in signalling at sea, as green lights were clearly visible at a distance of 8 miles.

At present lamp-black is manufactured from acetylene. It is of a deep black color and possesses excellent covering power. Acetylene gives from three to four times as much black as good oil gas. The application of acetylene as a motive power has not been developed as yet, although 160 liters of acetylene give 1 H.P. as against 600 liters of coal gas. The use of acetylene for enriching water gas in combination with other hydrocarbons presents a promising field for the future. Calcium carbide is used in the production of cement steel, for hardening armor plates and for the reduction of ores to pure metals and alloys. In chemical laboratories the acetylene Bunsen burner will undoubtedly be in-

* *Moniteur Scientifique*, October, 1900, 669. † Consular Report, Miscellaneous Series, No. 540, November, 1900.

troduced, its temperature being 2,700° C., as against 1,700° C. of a common Bunsen gas burner. The German state authorities have adopted acetylene gas lighting for various purposes. In Bavaria alone six railway stations will shortly be lighted by acetylene. The Imperial Post Office has installed 60 jets in the head post office in Berlin and two of its branch offices in Berlin are lighted by acetylene. The total number of acetylene jets throughout Germany cannot be given at present, but at the end of 1899 it was estimated to have been about 220,000, provided the rate of progress made between July, 1898, and the first months of 1899 had been maintained. At 40 normal candle power per flame this would give a total equaling 8,800,000 candles. This does not include the number of jets installed since the end of 1899, nor does it include the numerous jets of the acetylene oil gas mixture used so extensively by the German railways. The Prussian railways alone have consumed during 1900 about 5,000 tons of carbide for this purpose, the Bavarian railways about 600 tons and other German railways have consumed enough to bring the total consumption of carbide for railway lighting up to over 8,000 tons. Add to this the carbide consumed in the 8,000 large and small acetylene plants, and an approximate estimate of the consumption of carbide in Germany can be formed. For the production of carbide Germany possesses at present the following works:

Name.	Horse Power.	Remarks.
Bitterfeld		Steam power.
Rheinfelden	5,000	Water power.
Lechbruck	2,500	Water power.
Hagen	500	Steam power.
Phœnix, at Dortmund	1,000	Blast-furnace waste gases.
Lauffen, in Wurtemberg	600	Has ceased working for the present.
Frankfort		
Guttstadt		

The Ruhr Carbide Works with 2,500 H.P. (water power), is in course of construction. The capital of the above companies aggregates $1,650,000 and the total horse power 9,600. These works could produce, theoretically, about 9,000 tons annually, a quantity easily surpassed by importation. German capital therefore has been largely invested in other countries where water power was available for the production of carbide. The Allgemeine Carbid- und Acetylengesellschaft, in Berlin, has 1,500 H.P. at Sarpsborg, Norway, and 1,500 H.P. at Deutsch-Mattrei, Tyrol; Siemens & Halske, of Berlin, possess part of the carbide works at Wynau, Switzerland; Schuckert & Co., of Nuremburg, possess a part of the Lonza works, Switzerland, with 7,000 H.P., and at Iajce, Dalmatia, with 8,000 H.P.* These works furnish carbide for the German consumption and therefore the importation which amounted last year to $550,000 has decreased. The statistics for the first quarter of 1900 show a decline in the import which amounted to 1,800 tons for this quarter. The United States, which formerly held a monopoly of the import, has ceased shipping carbide owing to the progress of acetylene lighting, the home market consuming nearly all of the domestic product.

Germany does not possess large water power, still sufficient is found in the Bavarian mountain streams, where about 150,000 H.P. may be utilized with a

* Frederick Rose, *ob cit.*

prospect of financial success. If this available water power is used, then the German carbide market can be easily furnished with the German product for years to come, even if the consumption greatly increases, because this water power would produce, theoretically, about 140,000 tons per year. The reasons why German capital went abroad for producing carbide are as follows: the prices for water power abroad were very low and the great falls made the construction of long canals unnecessary. The cost of transportation of raw materials to these works and the cost of transportation of the finished carbide, however, has reduced these advantages practically to nothing. Cheap raw materials and a ready surrounding market are of greater advantage; in fact, to such an extent that steam carbide works have been erected in Hagen, Westphalia, and in Zomskowice, Russia. As will be seen from the table on preceding page, the Phœnix plant at Dortmund, which works with 1,000 H.P. utilizes the waste gases of the blast furnaces as power for the production of carbide. This source of power enters the field as a competitor of water power and tends to make countries possessing little water power partially independent of those which have an abundance of water power. Manufacturing countries, as the United States, England, and Germany, therefore, in the future may have carbide works operated by the waste gases from blast furnaces, particularly since manufacturing centers always have a thickly settled and large population, thus presenting a chance for a near and ready market for carbide with little or no cost for its transportation. In fact, it is expected that in Germany alone an additional 5,000 H.P. from the waste gases from blast furnaces will be used for the production of carbide. For instance, at Bochum, Westphalia, an installation is being constructed which will use several thousand horse power from waste gases, for the production of calcium carbide and other electro-chemical products. According to Liebetanz, of Düsseldorf, the cost of one horse power from this source varies from $15 to $22·50. As usual, this source of power will be developed by practice so as to reduce the cost by improved methods of securing and conducting the gases, as well as improvements in the special construction of gas engines for this purpose. The well-known gas machine works at Deutz on the Rhine is at present constructing 5 waste-gas engines, with a total of 9,000 H.P., of which four possess a capacity of 1,000 H.P. each.

The completion of works under construction has changed the state of the carbide industry, as compared with its condition two years ago, when the installation of new acetylene plants had surpassed the production of carbide, and high prices reigned. At present the reverse is the case. The production of carbide is in excess of the capacity of consumption on the part of the present acetylene installations. Enough capital has been invested at present in carbide companies and the time has arrived for the investment of additional capital to promote the introduction of acetylene lighting, and the outlook for shareholders and proprietors of carbide works is not very favorable. The crisis, however, is expected to be but temporary, and will rather benefit the acetylene industry, on account of the present low price of carbide. The prices of carbide in 1898 and 1899 and part of 1900 were as follows: they are given in marks (1 mark=24c.) per 1,000 kg., each kg. yielding about 300 liters of acetylene gas,

and do not include cost of carriage to place of consumption. Where it is not otherwise indicated the prices are for quantities not less than one wagon load (about 10 tons), f. o. b. Hamburg:

Prices of calcium carbide per metric ton in 1898 ranged from 390 to 600 marks. In 1899 from 450 marks in January to 345 in October. In 1900 from 350 marks in February to 210 in July.

A large amount of the carbide produced in Norway and Sweden is shipped to Hamburg and thence direct to South America and Australia, as the Norwegian and Swedish harbors do not possess direct transport facilities to these countries.

The number of firms in Germany engaged exclusively or partly in acetylene lighting and in the manufacture of carbide and other accessories is stated to be from 200 to 250. The largest of these are:

Name of Firm.	Amount of Capital Invested.	Name of Firm.	Amount of Capital Invested.
Allgemeine Carbid- und Acetylene Gesellschaft, Berlin	$400,000	Deutsche Acetylene Gesellschaft.	$115,000
Falbe & Co.	250,000	Keller & Knappich, Augsburg	125,000
Hera-Prometheus, Berlin	300.000	Bucher & Schrade, Mannheim	62,500
Butzke & Co.	85,000	Welkoborski, Giessen	37,500
		Thuringen'sche Gesellschaft	75,000

While electricity and coal gas have not been able to reduce the German consumption of American petroleum acetylene gas lighting may do so. A 5-ft. burner of coal gas gives 16 candle power and the same burner with acetylene gives in round numbers 250 c.p. One cu. m. of acetylene gas is equal to 16 liters of petroleum as regards lighting power, and as to the price it is at present somewhat cheaper than petroleum. In 1899, 911,000 metric tons of petroleum were imported into Germany. A supply of 600,000 tons of carbide requiring 600,000 H.P. would supplant the entire petroleum consumed.

According to Prof. Vogel,* the illuminating effect of 1 cu. m. of acetylene compares with other illuminants as follows:

	German Currency.	U. S. Currency. (Approximate.)
1 cu. m. acetylene	1·50 marks	36c.
6 liters of petroleum at 25 pf. per liter	1·50 "	36c.
16 cu. m. of coal gas burnt in open burners	2·72 "	65c.
4 cu. m. coal gas burnt in incandescent mantle	0·68 "	18c.
5 200-watt electric light	3·45 "	84c.

To the sum of 0·68 marks (18c.) for incandescent coal gas light (the Welsbach system), about 10% should be added for mantles, glasses, and loss in illuminating power. The above table shows that acetylene and petroleum command about the same price now and the tendency is that acetylene will sink while petroleum may rise in price, as violent and arbitrary fluctuation in the prices of imported American petroleum have been frequently experienced in the past. Acetylene lighting therefore is increasing, and plants in 30 towns in Germany have been erected or are in course of construction. The price of the gas per cubic meter varied from 1·9 to 2·8 marks.

In addition to these plants for small towns there are over 100 installations that use more than 500 jets. Many of the gas works above mentioned are managed by the municipal authorities and a few by private companies. The fact that town authorities manage the gas works shows that the alleged damage of acetylene

* British Consular Report. Miscellaneous Series, No. 540, November, 1900.

lighting is much less than generally believed. The public and private fire insurance companies in Germany have decided not to charge any additional premium for the insurance of buildings lighted by acetylene, provided that certain ordinary precautions are observed. During the year 1899 explosions and fires attributed to acetylene were six only, and these with one exception were due to culpable neglect, and would have occurred under the circumstances with any inflammable gas. The damage amounted to about $1,125. In the exception noted, the explosion and fire was caused by the thawing of frozen pipes. The number of fires caused by electricity during the same period was 85.

The acetylene lighting gas mixture used in railroad cars is perfectly safe. Experiments have proved that the mixture composed of one-half acetylene and one-half oil gas is no more liable to explosion than the pure oil gas itself. In practice, 75 parts of oil gas and 25 parts of acetylene are used, giving a threefold illuminating power, as compared with 100 parts of pure oil gas. The old oil gas burners are used with this mixture and if desirable the quantity of acetylene may safely be raised to 50 parts without necessitating any change in the railroad cars and compression rooms.

Since 1899, all trains within the Berlin Railway district are lighted by acetylene oil gas which is furnished by five works. As previously stated the German railways have consumed about 8,000 tons of carbide during 1900 for this purpose. Among the stations lighted by pure acetylene may be mentioned Hassfurt and Oberhausen, that were erected by Keller & Knappich of Augsburg.

The cost of oil gas, according to Railway Director Bork, as compared with pure oil gas and acetylene for the year 1898, shortly after its adoption is shown by the following figures:

COMPARISON OF THE COST OF OIL GAS, ACETYLENE OIL GAS, AND ACETYLENE IN 1898.

	Cost per Cubic Meter.		Cost per Jet.				Cost per Normal Candle Power.	
	Marks.	$	Hourly consumption in Liters.	Normal Candle power.	Marks. (a)	$	Marks.	$
Oil gas	0·30	0·075	27·5	5	0·01625	0·00390	0·00325	0·007800
Acetylene oil gas	0·54	0·135	27·5	15	0·02235	0·00584	0·00152	0·003648
Acetylene	1·30	0·325	12	15	0·02360	0·00566	0·00158	0·003792

(a) Includes a charge for depreciation and interest of 0·008 marks per jet per hour.

The above figures show that in 1899 the cost per hour and candle power by the new system of lighting with acetylene oil gas was only half as much as by the former oil gas lighting; further, acetylene oil gas and acetylene were practically equal in cost. Since 1899 the carbide prices have decreased considerably and have correspondingly reduced the cost of acetylene and acetylene oil gas lighting. 1,000 kg. calcium carbide cost 400 marks (about $96) in January, 1898. In June, 1900, the price for the same amount was 270 marks (about $65·50).

The steady growth of the German acetylene industry is further proved by the records of the Imperial Patent Office. In 1897, 617 applications were filed; in 1898, 973. The inventions for other illuminants have at the same time greatly decreased. In 1895, 304 patents were granted in this field, and only 209 in 1898.

India.—In India an application has been made to the Perak Government for a concession in the marble district of Kinta for the manufacture of calcium carbide. The carriage of calcium carbide by railway in packages of 150 lb. each has been permitted by the Government of India.

Norway.—The British Consul-General at Christiania reports that a new calcium carbide works has been erected at Meraker in the north of Trondhjem, and operations were recently commenced. The annual production of carbide will be about 2,500 tons and about 90 hands will be employed. The product will be shipped from Hommeloig and Trondhjem.

Russia.—In Russia there are at present in course of construction four works for the manufacture of calcium carbide. Two in western Russia, one in Finland at the Incatsu Falls, and one in the Comeg district. The works in Zomskowice, before mentioned, are working with steam power.

Switzerland.—M. A. Rossel read a paper before the International Congress of Applied Chemistry, at Paris, 1900, on the state of the carbide industry in Switzerland, in which the following *résumé* is given: The Neuhausen Co. greatly increased its plant and erected works at Rheinfelden, Siemens & Halske with the Wynau Co. erected works at Langenthal. At Neuhausen 2,000 to 2,500 H.P. are used from the fall in the Rhine for making carbide and aluminum. The Veriner works gets its power from the large hydraulic plant at Chevres; it utilizes about 7,000 H.P. The primary tension is 2,000 volts and a series of transformers reduce this to 200 volts to operate the furnaces. There are 13 furnaces; 12 using 500 H.P. and one, 1,000 H.P. The Langenthal works were destroyed by fire on June 5, 1900. The works on the river Lonza at Gampel utilize two of the falls of that river. The first fall has a head of 350 ft. and operates five turbines of 500 H.P. each, direct-connected to the low tension alternators, while the second fall, of 680 ft., drives 10 similar turbines with high tension dynamos; the two-phase system is used. The first fall gives 2,500 H.P. all of which is utilized for the production of carbide; the second fall gives 5,000 H.P. and one-half of its energy is used for the same purpose. M. Rossel describes several other plants, including the one of Vernoya, with turbines of 4,500 H.P., 900 H.P. of which is used for calcium carbide; Thusis, using 3,000 H.P., with 12 furnaces of 250 H.P. each; the Nidau plant, which disposes of 5,000 H.P. and uses 1,800 H.P. for carbide, and others. In the second part of his paper M. Rossel discusses the raw material used. Limestone of very good quality is found in Switzerland, which furnishes lime of 99% purity, and contains no trace of phosphoric acid. The calcium carbide delivered to commerce is guaranteed to give 4·8 cu. ft. of gas per lb., and generally it exceeds this by from 2 to 5%. Acetylene lighting is being adapted for public system as well as in a few factories.

United Kingdom.—The carbide works are located at Foyers, Bradford, Ingleton and Woodgreen. A considerable number of acetylene generators, lamps, carbide furnaces and improvements in the process of manufacturing carbide have been patented. Many of these patents were granted to foreigners, and of them, the one of W. Rathenau, of Berlin,* is most noteworthy. Raw

* English Patent No. 6,038, March 31, 1900.

materials containing iron and other metals or oxides are added to the mixture of lime and carbon in suitable proportions, so as to yield simultaneously a high percentage of calcium carbide, together with a compound of silicon and iron containing 20 to 25% Si, which is eminently suitable for industrial purposes.

General Remarks.—In good commercial calcium carbide the impurities that occur are silicon, in form of carbon silicide; calcium sulphide; iron, in form of silicide, or carbo-silicide; calcium phosphite and carbon in the form of graphite. According to H. Moissan,* chemically pure calcium carbide, which has been prepared by heating pure carbon from acetylene with either metallic calcium, its hydride or nitride, is colorless or white. Chemically pure calcium carbide in thin laminæ or small crystals is perfectly transparent. That the commercial calcium carbide owes its opacity and color to the presence of iron was shown by melting one of the pure specimens above mentioned with a trace of ferric oxide; after cooling, it presented exactly the appearance of the commercial product.

Accidental impurities in calcium carbide were analyzed by T. B. Ahrens.† He noticed in a specimen of calcium carbide a few metallic looking masses, that measured several centimeters in diameter. These were analyzed and found to be of the following composition: C, 1·03%; Si, 27·61%; Fe, 58·61%; and Cu, 12·76%; total, 100·36%. The metallic looking masses were thus a double silicide of copper and iron. Ahrens attributed the presence of this substance to a short circuit in the furnace, the iron being derived probably from the carbon holder and the copper from the leads.

The purification of acetylene gas by cupreous chloride or chromic acid is still carried on. The use of potassium permanganate and barium peroxide results in a loss of acetylene by oxidization. The purification by potassium chromite has proved inefficient. Bleaching powder containing 20·95% available chlorine has also been used for purifying acetylene gas, but it is reported that it corrodes metal burners. The corrosive action must be due to the chlorine compounds which may be removed by caustic potash or by slaked lime.

Among the chemical products proposed to be manufactured from acetylene by synthetical processes and polymerization, the manufacture of alcohol has received particular attention at Paris, Berne, and Berlin.

According to Birger Carlson,‡ the use of crude raw material is to be preferred in the manufacture of calcium carbide. He says that it is best to introduce the material into the furnace in pieces of the size of hazel nuts, because the gas formed during the process then has a free passage. Theoretically, 1,440 kg. of the mixture are required per metric ton of calcium carbide. The actual amount required in the experimental station of the Deutsche-Gold und Silber-Scheideanstalt was 1,590 kg. To be quite safe Carlson assumes that to produce 1,000 kg. of calcium carbide 1,700 kg. of material (*i.e.*, 1,000 lime and 700 coke) would be required. In calcium carbide works where the finely ground material is employed, as much as 3,000 kg. and more of the raw materials are needed per ton.

* *Bull. Soc. Chem.*, 1899, 21,921, 22. † *Zeitschrift für Angewandte Chemie*, 1900, 18, 439.
‡ *Zeitschrift für Elektrochemie*, 1900, 6, pp. 413, 429.

CEMENT.

THE combined output of Portland, natural and slag cements in 1900 exceeded that of the previous year by 2,000,000 bbl., the increase coming almost entirely from the Portland cement mills of Pennsylvania and New Jersey and the natural rock mills of the Kentucky-Indiana district.

PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES. (IN BARRELS OF 400 LB.)

States.	1899.			1900.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
California	48,000	$112,000	$2·35	51,000	$122,200	$2·20
Michigan	402,000	701,000	1·74	598,407	831,786	1·39
New Jersey	960,000	1,776,000	1·85	1,220,000	1,564,700	1·28
New York	507,931	939,672	1·85	446,664	611,930	1·38
Ohio	482,542	916,830	1·90	498,404	752,591	1·51
Pennsylvania	3,250,209	5,687,865	1·75	4,807,664	5,961,503	1·24
South Dakota	34,000	68,000	2·00	40,000	80,000	2·00
Utah	45,000	90,000	2·00	71,500	143,000	2·00
Other States (a)	75,038	150,064	2·00	258,000	394,200	1·53
Total	5,805,620	$10,441,431	$1·80	7,991,639	$10,461,910	$1·31

(a) Includes Arkansas, Illinois, Indiana, Kansas, Virginia, North Dakota, and Texas.

PRODUCTION OF NATURAL HYDRAULIC CEMENT IN THE UNITED STATES. (IN BARRELS OF 300 LB.)

States.	1899.			1898.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
Illinois	548,256	$137,275	$0·25	377,579	$116,500	$0·31
Indiana and Kentucky	3,034,344	758,586	0·25	3,488,392	732,562	0·21
Kansas	160 000	64,000	0·40	127,339	50,933	0·40
Maryland	325,000	132,250	0·41	195,242	80,418	0·42
Minnesota	103,986	51,993	0·50	56,403	28,201	0·50
New York:						
Ulster County	3,425,560	2,808,959	0·82	2,745,000	2,333,250	0·85
Onondaga County	139,586	68,672	0·49	139,765	72,488	0·52
Schoharie County	85,000	43,350	0·41	*Nil.*	*Nil.*	*Nil.*
Erie County	695,000	347,500	0·50	749,890	329,952	0·44
Ohio	21,597	19,437	0·90	25,000	15,000	0·60
Pennsylvania	700,034	420,020	0·60	703,612	281,445	0·40
Virginia	12,084	7,208	0·60	75,000	45,000	0·60
Wisconsin	411,000	173,450	0·42	412,000	156,560	0·38
Other States (a)	25,000	25,800	1·03	82,000	66,400	0·81
Total	9,686,447	$5,058,500	$0·52	9,177,222	$4,308,709	$0·47

(a) Includes Georgia, Tennessee, West Virginia, Florida and Texas.

Slag Cement.—The output of slag cement was 490,150 bbl., of 400 lb., valued at $622,490, against 244,757 bbl. ($360,800) in 1899. The prices declined

strongly, as manufacturers were compelled to meet the competition of Portland cement which, in addition to its claims of superiority for most purposes, sold at very low figures in the large manufacturing centers. There were six plants in operation, the same as in the previous year. By the decision of a board of engineers officially appointed, it has been decided that "Steel Portland Cement" cannot be substituted for Portland cement in government work where the specifications call for the latter, but is to be classed as puzzolana slag cement.

CEMENT PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION IN THE UNITED STATES. (IN BARRELS OF 300 LB.)

Year.	Production.				Imports.		Exports. (b)		Consumption.	
	Natural Hydraulic.	Portland. (a)	Total Barrels.	Value.	Barrels.	Value.	Barrels	Value.	Barrels.	Value.
1896.....	7,407,311	2,103,044	9,510,355	$6,888,441	3,558,166	$3,394,426	87,910	$103,315	12,980,611	$10,179,552
1897.....	7,890,573	3,294,537	11,185,110	7,760,955	2,787,766	2,688,122	79,583	103,389	13,893,293	10,345,688
1898.....	8,161,078	4,989,664	13,150,742	10,223,822	2,685,092	2,624,228	70,892	98,121	15,764,942	12,749,929
1899.....	9,686,447	8,067,161	17,753,608	15,860,731	2,810,951	2,858,286	147,029	213,457	20,417,530	18,505,560
1900.....	9,177,322	11,309,052	20,486,274	15,393,109	3,182,245	3,330,445	186,586	289,186	23,481,933	18,434,368

(a) Includes slag cement. (b) Includes re-exports of foreign.

IMPORTS OF CEMENT INTO THE UNITED STATES ACCORDING TO SOURCE.

Year.	Belgium.		Canada.		France.		Germany.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1896.....	140,197	$813,827	2,096	$17,777	6,531	$38,317	246,666	$1,629,785
1897.....	109,531	649,675	981	9,311	7,545	44,574	221,856	1,467,845
1898.....	133,806	80,949	955	8,852	3,459	22,224	206,982	1,394,551
1899.....	124,830	747,448	880	8,868	3,130	22,262	238,799	1,693,722
1900.....	165,258	1,001,122	903	9,396	6,542	47,793	231,110	1,722,104

Year.	United Kingdom.		Other Countries.		Total Imports.		Exports. (a)	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons	Value.	Short Tons.	Value.
1896.....	126,268	$808,550	12,056	$86,615	533,725	$3,394,426	13,186	$103,315
1897.....	68,869	451,256	9,380	65,461	418,165	2,688,122	11,937	103,389
1898.....	47,212	333,405	10,350	64,247	402,764	2,624,228	10,633	98,121
1899.....	39,927	309,614	14,112	76,372	421,643	2,858,286	22,054	213,457
1900.....	53,584	416,937	19,939	133,093	477,337	3,330,445	27,988	289,186

(a) Estimated from number of barrels reported at 1 bbl.=400 lb. Includes re-exports of foreign.

Natural Rock Cement.—Manufacturers were inclined to limit the output of their mills until they could dispose of the stocks held over from the previous year, and in nearly all the districts a decreased production was reported. A marked exception may be noted in the Kentucky-Indiana region which produced a total of 3,488,392 bbl., as against 3,034,334 bbl. in the previous year, but the increase fell short of that of 1899. In the Rosendale district of New York the manufacturers entered into an agreement to curtail the output, in consequence of which there was a decrease of about 700,000 bbl. Prices for natural cement were lower generally, although in a few instances where the supply was short, they were maintained at about the level of the previous year, or slightly increased. Very little activity was manifested in the construction of new plants. The total capacity of the mills in the United States in 1900 was about 12,000,000 bbl.

The Cement Industry in the United States in 1900.

By Frederick H. Lewis.

The closing year of the century was made notable in the Portland cement trade, by overproduction, and the lowest prices in the history of the industry. Many of the old plants entered the year with a largely increased capacity and full stock houses, and a number of new plants in various parts of the country were placing their products on the market. Also there was a pause in nearly all lines of construction, due to building trade strikes and the presidential election. From these causes, prices fell sharply in June, and lower and lower figures were quoted throughout the summer and early fall. After the election there was a sharp demand for cement but without however increasing prices. Manufacturers were naturally eager to unload their surplus stocks rather than to carry them through the winter. The result was that prices of cement delivered on works in New York City fell as low as $1·40 per bbl., and in Chicago as low as $1·60.

In spite of these very low prices, it is believed that the larger and better organized plants were enabled to enforce and carry out economies by which they sold cement at a profit. The smaller and less favorably situated concerns were not able to do this, and their business was naturally restricted to such markets as they could get into without facing strong competition. The year 1901 is quite certain to see considerable recovery from these low figures, but it is also quite certain that the old range of prices will never again be realized.

Some 15 or 20 years ago the Trunk Line Railroads discovered that the rates they had in force and the dividends they were able to earn were active and continuous incentives to the building of competing lines, and they adopted a policy of lower rates and smaller dividends. In precisely the same way, the larger cement manufacturers, particularly those in the Lehigh Valley region, are discovering that their prices and profits have led to the extensive promotion of new plants in all parts of the country, and that they must forestall this competition by a considerably lower margin of profit.

Unquestionably this state of affairs in trade has given pause to a number of projected enterprises whose prospectuses have boldly claimed a profit of 80@ 90c. per bbl. between selling price at mill and cost of manufacture. It has naturally been necessary to recast entirely the calculations of various prospectuses, based on figures of this character, and the revision has not been so attractive to investors.

In regard to the cost of production it may well be doubted whether any locality in the United States offers much advantage over the Lehigh Valley region in Pennsylvania and New Jersey. Certain it is, that the size, organization and experience of the Lehigh Valley manufacturers would at the present time much more than offset any advantage which new plants might have elsewhere. New enterprises therefore have to consider at the outset whether they are prepared to meet the lowest prices which Lehigh Valley manufacturers are prepared to entertain. The direct effect of this state of affairs will be the elimination of the smaller enterprises. Other things being equal, a large plant will produce cement at a considerably lessened cost than a small one. The day of small things in

the cement industry may be regarded as past. Plants to operate successfully must be able to command cheap raw materials—the cement rocks and coal. They must be able to gain access to markets on favorable terms and they must manufacture on a large scale.

The question of low prices also brings directly to the front the issue between the wet and dry process of manufacture. A number of small enterprises have been in existence for years in New York, Ohio and Michigan, using the wet marls and clays as the raw materials for Portland cement mix. Indeed the wet and dry processes of manufacture in America both began in 1875, when Saylor made Portland cement by the dry process at Coplay, and Millen by the wet process at South Bend, Ind. Very large enterprises using wet process are now projected, especially in Michigan, their market being naturally in the great lake cities. None of the smaller and earlier wet plants has been notably successful, nor has grown to large proportions. On the other hand, the Pennsylvania plants, using hard materials, have prospered to a notable degree and developed very large enterprises. The inference from this fact alone is that there are economies in the dry process, which make it more profitable than the wet. It remains to be seen therefore whether the large enterprises now projected to use the wet raw materials of Michigan, Ohio, Indiana, and New York, are justified in their undertakings or in their estimates of what they can accomplish as compared with other Eastern competitors.

At the present writing, there seems to be considerable evidence to show that the fuel cost of production in rotary kilns is much lower with dry materials than with wet; a conclusion naturally anticipated. Furthermore the facts seem to indicate clearly that much larger output per kiln can be obtained from dry materials than from wet. On the other hand, the preparation of wet materials for the kiln is undoubtedly cheaper than is the case with dry materials.

As a rule when prices are low in any line of manufacture, customers are more exacting than usual, and this has been apparent to some extent in the cement trade during the past year, but the weight of opinion among many of the better informed engineers, and in the majority of the testing laboratories has shown a reaction from high test requirements, and from the so-called accelerated tests, which had considerable vogue a few years ago. In many laboratories, series of long time tests have been maturing and the results were not favorable to very high testing cements, nor did they confirm the value of boiling water tests for cement. There seems to be little doubt that the best opinion in this country will soon approach the position held by the European experts, favoring moderate tests at short periods and discrediting the value of the accelerated tests.

The reactions of acids and bases in a Portland cement undoubtedly vary considerably with different raw materials, and these reactions are variously affected by the addition of calcium sulphate as a retarder. The investigation of these effects abroad has convinced the chiefs of laboratories in France, England and Germany that it is quite unsafe to ascribe a failure to meet the so-called boiling test as due to uncombined lime, or to indicate that the cement would be unsound under normal conditions. Of course, each new laboratory taking up the investigation of cement for the first time is likely to pass through these various stages

of opinion, arriving at conclusions as the facts mature. Some extremely interesting results have been obtained by new investigators in the analysis and tests of cement, the most interesting example of which is the report issued by the Commissioners of Accounts for the City of New York, May 24, 1900, entitled "Comparison between Physical Tests and Chemical Analyses of Thirty-four Samples of Portland and Rosendale Cements." With entire good faith and a great deal of labor, some very interesting and enthusiastic conclusions have been reached, which however are not likely to survive the test of time.

Nothing novel in the way of burning or grinding materials and clinker for Portland cement has been developed during the past year. At many points various labor-saving devices have been introduced, which are effecting quite important reductions in labor cost and it is believed at the present time that representative American companies, whose equipment is modern and whose plants are large, are making cement in this country as cheaply as it is made anywhere in the world.

The American rotary kiln, which has been the greatest factor in the development of American cement manufacture, is now finding favor abroad. A patent was taken out for it in England, by Mr. Frederick Ransome, in 1885, and it was first put to practical test at Grays, on the Thames River, in Essex. The practical difficulties however of using it proved to be so great and the fuel consumption so large, that it was abandoned in England entirely. Its successful development therefore is distinctly an American result. It is interesting to note that a very large company, of which the old firm of J. B. White & Co. is the center, has been organized to build rotary kilns in the Thames and Medway district, England, and that other interests there are also experimenting with these kilns. In Germany the Hemmoor Co. is said to be operating kilns of the rotary type with great success and other plants are being projected. In France the Parisian Portland Cement Co. is operating one at Dennemont, on the Seine River, below Paris. These kilns abroad are said to make a better quality of cement than the shaft kilns can produce, and in Germany a greater economy of production is claimed.

New Plants in Operation.—A considerable number of new plants went into operation last year. In Pennsylvania in the Lehigh Valley, the Lawrence Cement Co. started a large plant at Siegfried Bridge, Northampton County. The White Hall Cement Co., at Cementon, Lehigh County, placed a similar plant in operation. The Coplay Cement Co., Coplay, started an 8-kiln rotary plant—the first installation of rotary kilns by this company whose older works have been in operation for many years. The Atlas Co. added a number of rotary kilns to their previous large plant, at Siegfried. The Phœnix Portland Cement Co., at Nazareth, started a 2-kiln Portland plant. The Wm. Krause & Sons Cement Co. started a 4-kiln plant, at Martins Creek, on the Delaware River, some 7 miles north of Easton. The Lehigh Portland Cement Co. started their mill "B," at Ormrod, with 8 additional kilns. All of these plants utilize the well-known cement formations of the Lehigh Valley region as their raw materials.

In New York the Catskill Portland Cement Co. placed in operation a cement plant at West Camp, on the Hudson River, above Kingston. The raw materials

used by this company are a highly crystalline fossiliferous limestone, known in the State geology as the Beecraft limestone, which is found adjacent to the brick clays of the Hudson River valley, in the foot hills of the Catskill Mountains, near the river. The principal advantage at West Camp is the extremely low cost of transportation afforded by the Hudson River. Bulk freights by barge on the river are so low that it practically makes New York City the distributing point for this product.

In Virginia, in the spring of 1900, the Virginia Portland Cement Co. placed a 4-kiln rotary plant in operation at Craigsville. This plant was intended to supply the growing trade of the South, and it utilizes as raw materials, a vast deposit of crystalline fossiliferous limestone, locally known as "Coral Marble," in conjunction with a fine deposit of hard, black shale. Both rocks are of unusual purity, the shale being exceptionally fine.

In Ohio, the Alma Portland Cement Co. started a small rotary kiln plant, at Wellston, using limestone and clay as their raw materials.

In Illinois, the German-American Portland Cement Co. started a plant at La Salle, using limestone and a soft clay as raw materials. The Illinois Steel Co. placed on the market a Portland cement, the raw materials of which were furnace slag and Bedford limestone. The Chicago Portland Cement Co. operated shaft kilns of somewhat novel design, at La Salle.

In Kansas, the Iola Portland Cement Co., at Iola, placed in operation a 12-kiln rotary plant. This company was organized by Messrs. Holmes and Beaton, of Detroit, who had previously organized the Michigan Portland Cement Co., with works at Coldwater, Mich. The chief advantage seems to have been an available supply of natural gas. This gas supply is described as a 10,000,000 cu. ft. gas well, and the company has installed Westinghouse gas engines, utilizing natural gas directly without boiler installation. Natural gas is also used as fuel for the kilns, where it should prove ideal. With an abundant supply of natural gas the economy of operation at this point should be quite unusual. The history of other gas fields, however, has shown natural gas to be a vanishing factor and the continuous success of this plant will probably depend upon the demands made upon the available supply of natural gas.

In Michigan, the Omega Portland Cement Co., with offices at Jonesville and works at Mosherville, started a plant of four rotary kilns, utilizing marl and clay as the raw materials.

In North Dakota an experimental plant of one rotary kiln was built by the Pembina Co., on the Tongue River, near the Canadian boundary line.

Plants Under Construction or Projected.—In Pennsylvania and New Jersey in the Lehigh and Delaware River district there is no apparent abatement in activity of growth.

In Pennsylvania the Dexter Portland Cement Co. is building a 4-kiln plant about a mile west of Nazareth, and will have it in operation early in 1901. The company owns 250 acres of limestone and slate land and is equipping a complete modern plant. The Phœnix Co. also purposes to enlarge its plant at Nazareth. An 8-kiln plant is in process of construction 2 miles east of Nazareth by the Northampton Portland Cement Co. It is to produce 1,200 bbl. of cement per

day. The Lawrenceville Cement Co., of New York, is reported to have planned a 1,000-bbl. mill to be built in Northampton County.

The Reading Cement Co., with works at Evansville, is reported to be ready to place its products on the market.

In New Jersey the Edison Portland Cement Co., capitalized at $11,000,000, proposes to erect a very large plant at Stewartsville. The Alpha Portland Cement Co., in Warren County, is building an 8-kiln extension to their present plant, giving them a total installation of 18 kilns. The Vulcanite Co., also in Warren County, is preparing plans for a 10-kiln plant as an addition to their present installation of 11 kilns. The Alsen American Portland Cement Co. is erecting a plant on the Hudson River shore at West Camp. This plant is being built by parties interested in the well-known Alsen Cement Co., of Hamburg, Germany. The location of the plant is close to that of the Catskill Portland Cement Co. alluded to above, which was started at West Camp last year. Both companies utilize the same raw materials—the Beecraft limestone, and the Hudson River brick clays.

In West Virginia, the Buckhorn Portland Cement Co. has under construction a plant at Rowlesburg, on a branch road connecting with the Baltimore & Ohio Railroad. This company's plans provided for the installation of six kilns and the raw materials to be used are hard gray limestone and soft clays.

In Alabama, a 3-kiln rotary plant is under construction at Demopolis, on the Tombigbee River.

In Tennessee a large deposit of so-called natural Portland cement rock is reported to have been discovered near Chattanooga, and it seems probable that a plant for the production of either Portland or natural cement will be erected at this point.

In Michigan at the present time, there is great activity in promoting new plants for the production of Portland cement. The Great Northern Portland Cement Co., capitalized at $5,000,000, with offices in Detroit, proposes to build a 20-kiln plant near Baldwin, Lake County. The raw materials available there are wet marls, found in the rivers and lakes, and soft clays. This company has placed contracts for nearly all of its structural work and machinery. The Alpena Portland Cement Co., of Alpena, reports that its plant is practically completed. The present installation is six rotary kilns, and the works are planned to double this capacity. The materials at this point are limestone and clay. The location is on Thunder Bay, Lake Huron, and extensive docks are under construction for shipping by lake. The Zenith Portland Cement Co., with a capital stock of $700,000, is reported to have under contract an 8-kiln rotary plant, at Grass Lake. The raw materials to be used are the wet marls and clays of the Michigan lakes. Detroit capitalists are erecting a plant at Jackson for the Peninsular Portland Cement Co. The estimated capacity is 1,000 bbl. per day, and it is proposed to manufacture cement from marl and clays. It is understood that the company will utilize water power to generate electricity, and will equip its plant with electric motors. At Elk Rapids the Elk Rapids Portland Cement Co. is reported to be building a 600-bbl. plant. The raw materials are marl and clay. A large plant is projected at Newaygo, and it is claimed that the company controlling it

has very large deposits of pure white marl, and water power in the Muskegon River. A 750-bbl. plant is in contemplation to be placed in operation in 1901.

In Indiana, the Sandusky Portland Cement Co. is reported to be erecting an 8-kiln plant in Syracuse, and the Monolith Portland Cement Co., at Bristol, owns large deposits of marl and clay as well as water power in the St. Joseph River. It expects to build a large plant with the idea of supplying the Chicago market.

Output and Consumption.—The production of cement in the German Empire is variously estimated at from 15,000,000 to 18,000,000 lb. per annum, and that of the British Islands at from 12,000,000 to 14,000,000 lb. It is quite evident from the tables of production for 1900, preceding this article, and from the account given above of the new plants under construction and projected, that the production of Portland cement in the United States will soon exceed the present English output, and it is likely before many years to rival that of Germany. These countries have been very large exporters of cement for many years, not only to America, but to all parts of the world, and it is important to consider, therefore, whether the growth of the industry in America is not unhealthy, and whether it is not likely to exceed the demands of the market. This is especially important, since the year 1900 in the United States, was undoubtedly marked by an overproduction of cement accompanied by low prices. In regard to the low scale of prices prevailing in 1900, it is to be added that there was a large importation of foreign cement during the winter of 1899-1900, especially German cement, that was due to poor business conditions in Germany, which exported a large quantity of its cement to America in anticipation of high prices. In considering this question of demand and supply in respect to cement, we shall necessarily have to look to European precedents.

For many years the English and German producers of Portland cement have been large exporters of cement to all parts of the world, nevertheless, it is estimated that the German Empire uses within its borders from 10,000,000 to 12,000,000 lb. per annum. This is in a country with a population of 50,000,000, covering a comparatively small territory, and while growing and progressing, it is nevertheless a land of an old and well established civilization, with its principal public works long since completed. In America the population is 75,000,000, and the territory 15 times as great. The system of public works in all parts of the country has immense projects in view and in many sections there has been no development of roads, bridges, water works, or drainage at all comparable to that of the German Empire. Yet with all the great demand in their own country it may reasonably be expected of the future that American producers will export large quantities of cement, if proper shipping facilities are provided for this purpose.

The qualities of Portland cement meet a great variety of uses and create markets for it everywhere. Wherever factories are established the local demand for it soon becomes large. There does not seem to be, therefore, any reasonable doubt that the United States can readily consume an output at least as large as that of the German Empire, if not considerably larger. It is quite apparent, however, that if this is to be the case, the price of cement must be placed much lower than it has been heretofore.

CHROMIUM AND CHROME ORE.

THERE has been no production of chrome ore in the United States during 1900, the mines in California still remaining closed and the usual small output from the Pennsylvania mines having come to a standstill. Chrome ore is used mainly for the manufacture of iron and steel alloys, which when added to the bath of molten steel impart to it special properties as outlined in the section on "Iron and Its Alloys," under the caption "Iron and Steel," found elsewhere in this volume. The adoption of Krupp armor plate for protective purposes for war vessels and the activity of several nations in increasing their navies have attracted general attention to the use of ferrochromium in the manufacture of steel. Apart from armor plate and armor-piercing projectiles, ferrochromium is used in the manufacture of tool steel, wire, magnet steel, cutlery, bridge steel, safes, tires, axles, springs, stamp-mill shoes, crusher jaws and knuckles for car couplings. While the consumption has increased the plants manufacturing the alloy have expanded more rapidly than the demand for their products, resulting in a decline in price of from 20 to 25% during the year. Early in 1900 three concerns in America were devoted exclusively to the manufacture of ferrochromium, one at Hamilton, Canada, with an output of 300 tons per year, one, The Alloy Smelting Co., at Niagara Falls, N. Y., of about the same capacity, and the third, The Willson Aluminum Co., with works at Holcomb Rock, Va., and Kanawha Falls, W. Va. During the year The Alloy Smelting Co. has doubled the capacity of its plant and The Willson Aluminum Co. has increased its capacity threefold. The total consumption of ferrochromium in the United States is estimated at 1,900 tons and the average analysis of the American product is: Cr, 71·215%; Fe, 22·5%; Si, 0·465%; S, 0·06%; P, 0·008%, and C, 5·65%. Owing to the necessity for extreme purity the chrome iron ore used for the manufacture of ferrochromium is imported from Asia Minor, the reduction being accomplished in an electric arc furnace. The chrome iron ore from Canada contains too much silica to admit of its use for the manufacture of

PRODUCTION, IMPORTS AND CONSUMPTION OF CHROME ORE IN THE UNITED STATES.

Year.	Production.			Imports.			Consumption.	
	Quantity. Long Tons.	Value Per Ton.	Value.	Quantity. Long Tons.	Value Per Ton.	Value.	Quantity. Long Tons.	Value.
1896.....	702	$11·07	$7,775	8,869	$21·13	$187,400	9,571	$195,175
1897.....	150	10·33	1,550	11,566	16·11	186,313	11,716	187,863
1898.....	100	10·00	1,000	16,304	16·70	272,234	16,404	273,234
1899.....	100	10·00	1,000	15,793	18·03	284,825	15,893	285,825
1900.....	*Nil.*	*Nil.*	*Nil.*	17,542	17·39	305,001	17,542	305,001

ferrochromium by the electric furnace method, the heat in this process being so great that silicon is reduced from the silica of the ore and enters the ferro alloy in too large an amount for good quality of product. The Canadian ore is mainly used for the manufacture of chrome alum and other chromium salts as well as for a refractory material for furnace linings.

North Carolina.—During the past year there has been no chrome ore mining or development work in this State. The working of the chrome deposits near Balsam Gap, Jackson County, under the control of the National Abrasive Co. was contemplated, but nothing was done. The deposits near Webster, Jackson County, have not been operated during the past two or three years beyond taking out an occasional few hundred pounds for samples, and the deposit at Mine Fork, near Burnsville, Yancey County, is still too far from the railroad to attract any considerable interest. A railroad from Marion across the Blue Ridge Mountains to Erwin, Tenn., is proposed, which, if built, will render the deposits at Mine Fork accessible.

THE WORLD'S PRODUCTION OF CHROME ORE. (*a*) (IN METRIC TONS.)

Year.	Bosnia.	Canada.	Greece.	New Caledonia (*b*)	Newfoundland.	New South Wales.	Norway.	Russia.	Turkey. (*b*)	United States.
1895.....	707	2,882	2,740	8,014	44	4,297	190	21,014	21,050	1,578
1896.....	443	2,124	1,600	16,018	1,031	3,914	*Nil.*	6,682	20,137	713
1897.....	396	2,392	563	9,054	3,084	3,433	*Nil.*	13,433	11,551	152
1898.....	458	1,833	1,367	14,300	657	2,145	*Nil.*	(*c*)	(*c*)	102
1899.....	200	1,796	4,386	12,480	640	5,327	(*c*)	(*c*)	*d* 4,538	102

(*a*) From the official statistics of the respective countries, except for the United States, which are our own. (*b*) Exports. (*c*) Statistics not yet published. (*d*) Exports from Salonica and Smyrna.

Canada.—The ore in the eastern townships of Quebec occurs in the serpentine belt, which also includes the asbestos mines. The exploitation of these deposits began in 1894, and the methods of working them are as yet generally primitive. The richest ores only have been extracted, but with the development of the industry it is probable that the poorer deposits will be of value. According to official returns the output in 1900 was 2,118 metric tons, valued at $27,000, against 1,796 tons ($23,760) in 1899.

Greece.—The output of chrome ore in 1900 was 5,600 metric tons, valued at $70,200.

New Caledonia.—Chrome ore was discovered in 1875, and the principal deposits of value occur in the serpentines of the mountains in the southern portion of the island. The dark serpentines that have weathered with a bluish crust are considered by the miner to be favorable rock for the occurrence of chrome ore. While the exact nature of the deposits has not yet been fully proven, F. Danvers Power, in a paper read before the Institution of Mining and Metallurgy, London, May 16, 1900, is inclined to the opinion that the various so-called lenses of ore are connected. The serpentine occurs in bands and the longer axis in chrome ore lenses corresponds with the general strike of the bands. The ore does not occur in a solid mass, but is found in the joints of the serpentine from which it is separated on the outside of the workable deposits by a strict line of demarkation, although the serpentine beyond the lens contains

grains of chromite. Both chromite and picotite vary considerably in composition, the following limits being obtained from several analyses of minerals from various parts of the world:

Components.	Alumina. Al_2O_3.	Ferric Oxide. Fe_2O_3.	Magnesia. MgO.	Silica. SiO_2.	Chromic sesquioxide. Cr_2O_3.
	%	%	%	%	%
Picotite.....	5—5	3—24	10—23	0—2	7—8
Chromite.....	0—19	18—38	0—18	0—10	39—66

Chromite, the only ore of chromium that is worked for that metal, is classified by the miners as "alluvial chrome," "red chrome" and "rock chrome." The alluvial chrome or, better, the "saprolite" (as the earthy rock has not been transported) has resulted from the weathering of the serpentine, and it forms a capping of the chrome deposit, sometimes 30 ft. or more in thickness. The chromite is present in its original position, although it has been broken up into small grains. This class of ore is of the most value for, although poorer in chromium than the rock deposit, it is nearer the surface and more easily concentrated by washing. The alluvial chrome gradually merges into the less disintegrated chromite ore termed "red chrome" from its iron stained color, and below this layer is the black or "rock chrome." The rock chrome ore is contaminated with serpentine and other minerals to such an extent that, apart from a few handpicked specimens, it is too poor for market purposes and requires to be reduced artificially before it can be dressed to the proper quality. The lenses of chromite are of large size; the "Lucky Hit" has yielded 13,000 tons; the Pénsee, 14,000 to 15,000 tons; the Joséphene, 18,000 tons, and the Alice Louise, 10,000 tons. The two last named deposits are still being worked. Pure chromite contains 68% Cr_2O_3 and the ore for the market is required to contain at least 50% Cr_2O_3. A leeway of a few per cent. above this limit is usually made to allow for the differences in sampling and assaying. The usual impurities in chromite are silica, magnesia and alumina, the first being the most objectionable. The method of concentrating the ore is usually by means of a common sluice box through which a current of water flows, the ore being worked up the sluice against the current and the lighter particles of gangue thereby removed. The enriched ore is discharged, dried and bagged for shipment. Other simple methods of ore dressing are used. At one mine the ore is tipped into a sluice box, 2 ft. wide, 1 ft. deep, which is placed at an angle of 20°. From this it passes into a wider and shallower sluice, pitched at a slighter incline, which gradually terminates in a level. The chrome ore which has settled in the sluice box is removed and passed through a 16-mesh sieve into a vertical box provided with five inclined shelves overlapping from opposite sides. The material is well agitated with water as it falls from shelf to shelf and finally passes into a lower sluice box. If necessary the latter part of the process is repeated, after which the concentrates are dried and bagged.

Newfoundland.—New discoveries of chromite are reported on the west coast, but there was no output from the mines in 1900.

New South Wales.—The output of chrome ore in 1899 was very satisfactory,

5,243 tons, valued at £17,416 being exported compared with 2,111 tons, valued at £6,301 in 1898. The mineral at present is mined only at Quilter's Bros. mine in the Gundagai division. The total amount of chrome ore produced in the Colony from 1882 to 1899 was 20,949 tons, valued at £70,975.

Turkey.—The reported shipments of chromite from Salonica and Smyrna in 1899 amounted to 4,467 long tons, valued at $94,740. These figures represent only a part of the exports, as smuggling is constantly carried on to avoid export duty and many times the ore is probably shipped as iron ore.

TECHNOLOGY.

There has been nothing new on record in the metallurgy of chromium and ferrochromium. The furnace practice as formerly carried out in Germany is fully described by Dr. W. Borchers in his notes in THE MINERAL INDUSTRY, Vol. VIII. The present method of manufacture, however, is accomplished by the direct application of the electric arc furnace. For the physical properties of special chrome steels reference should be made to the paper on "Iron and Its Alloys," given elsewhere in this volume.

Analysis of Chrome and Tungsten Steels.—A. G. McKenna* describes analytical methods which have been found entirely satisfactory in the analysis of several hundred samples of steel containing both chromium and tungsten. Sulphur, silicon, tungsten, chromium and manganese are determined in one portion of the crushed steel; 5 g. of the sample are dissolved with the aid of heat in a flask with 30 c.c. of hot water and 30 c.c. of strong hydrochloric acid, the sulphur being liberated as hydrogen sulphide which is absorbed in ammoniacal solution of cadmium chloride and determined by titration with iodine. The solution of the steel is evaporated to dryness with 10 c.c. of strong nitric acid, the mass dissolved in 15 c.c. of hydrochloric acid and the solution again evaporated to dryness. The dry mass is dissolved in 20 c.c. of hydrochloric acid, the solution diluted with 100 c.c. of water and filtered. The silica and tungstic acid remaining on the filter are ignited and weighed, and after the removal of the silica by hydrofluoric acid the remaining tungstic acid is weighed alone. If the substance contains iron oxide, the tungstic acid is removed by fusion with sodium carbonate and solution in water, and the weight of the ferric oxide remaining deducted from the weight previously found. The filtrate from the mixture of silica and tungstic acid is evaporated with 50 c.c. of strong nitric acid until all the hydrochloric acid has been removed, the liquid made up to 200 c.c. with strong nitric acid and evaporated to 75 c.c. with 10 g. potassium chlorate in order to precipitate the manganese and convert the chromium into chromic acid. The manganese dioxide is removed by filtering through an asbestos plug while hot, redissolved in hydrochloric acid, traces of iron removed by precipitation as basic acetate and the manganese precipitated with bromine in a strongly ammoniacal solution, and weighed. The filtrate from the manganese dioxide is diluted to 500 c.c., cooled to 20°C., and the chromic acid determined by the addition of a measured quantity of standard solution of ferrous sulphate, the excess being titrated back with potassium manganate.

* *Proceedings of the Engineers' Society of Western Pennsylvania*, April, 1900.

For the estimation of phosphorus 5 g. of the steel is dissolved in nitric acid and evaporated to dryness, the solution being aided in case the steel contains more than 1% Cr by adding hydrochloric acid from time to time before the evaporation has proceeded too far. The residue is baked as usual, the mass dissolved in 20 c.c. of hydrochloric acid, the solution evaporated to dryness, the residue again dissolved in 20 c.c. of hydrochloric acid and the solution diluted and filtered to remove the silica and tungstic acid. The solution is treated with 35 c.c. of strong ammonia, the precipitate redissolved with 40 c.c. of strong nitric acid, and the phosphorus precipitated with 100 c.c. of molybdate solution, shaking a few minutes and allowing the mixture to stand one hour. The phospho-molybdate is collected and weighed upon a tared filter.

For the estimation of carbon 1·5 g. of steel are dissolved in 100 c.c. of a 33% solution of cupric chloride and potassium chloride, the solution being hastened by the addition of 5 c.c. hydrochloric acid after the mixture has been allowed to stand one-half hour. The carbon is collected upon an ignited asbestos plug and burned in oxygen, the carbon dioxide being collected in the form of barium carbonate in a 10-bulb absorption tube.

Determination of Chromium in Steel.—According to E. Döhler* the sample is dissolved in hydrochloric acid and from the solution the chromium is precipitated by repeated treatment with excess of barium carbonate in a closed flask. The precipitate thus obtained is fused in a porcelain crucible with a mixture of potassium-nitrate and potassium-sodium carbonate. The chromium salts are extracted from the fused mass by treatment with water and the estimation then proceeds in the customary manner.

Rapid Determination of Chromium in Alloys.—Ibbotson and Brearly† suggest an expeditious method for the determination of chromium in the alloys of iron, chromium, tungsten and manganese. The sample is decomposed with hydrofluoric and nitric acids; sulphuric acid added and the solution evaporated to fumes. Chromium in the diluted solution may then be determined easily by the Galbraith process or by Stead's modification of it. An additional advantage of this method of starting the solution is that after dissolving the precipitated manganese dioxide with hydrochloric acid, the tungsten may be estimated by filtering off the tungstic acid and removing the chlorine from the solution by boiling, which renders the action more quiet.

Estimation of Chromium in Chrome-Tanned Leather.—Paul Schroeder‡ determines chromium in chrome-tanned leather as follows: The ash of 3 g. of the leather is heated upon the water bath with 60% nitric acid and a little potassium chlorate and, for the complete oxidation of the chromium, the solution is evaporated to dryness a second time if necessary. After diluting with hot water and filtering, the solution is repeatedly evaporated to dryness and taken up with hydrochloric acid. The chromium, now in the form of chromium sesquichloride, is oxidized by Clark's method with sodium peroxide, the excess hydrogen peroxide being removed by evaporation with a few drops of alcohol. The residue is treated with 25 c.c. of a 10% solution of potassium iodide and 25 c.c. of sul-

* *Chemiker Zeitung*, Vol. XXIII., p. 868. † *Chemical News*, Nov. 21, 1900.
‡ *Deutsche Gerber Zeitschrift*, 42, 153.

phuric acid (1 in 5), and free iodine titrated with a tenth normal solution of sodium thiosulphate using starch as an indicator. One part of dry sodium thiosulphate corresponds to 0·11076 part chromium, or 0·16177 part chromic oxide. The amounts of chromic oxide found in the analysis of seven samples of different kinds of chrome-tanned leather by this method varied from 1·99 to 4·95%.

Iodometric Estimation of Chromic Acid.—K. Seubert and A. Henke* have investigated the conditions under which the reaction between chromates and iodides in acid solutions may be employed for the estimation of chromic acid. If the compounds are present in the proportions indicated by the equation $K_2Cr_2O_7+6KI+14HCl=8KCl+2CrCl_3+7H_2O+6I$, the iodine is liberated too slowly for analytical purposes. The authors found the proportions $K_2Cr_2O_7+18KI+70H_2SO_4$ suitable, the reaction being complete in six minutes. In 100 c.c. of solution there should be 0·5 g. $K_2Cr_2O_7$, 0·5 g. KI and 1·8 g. H_2SO_4. When the reaction is complete the solution is diluted and titrated with standard sodium thiosulphate, using starch as an indicator.

The Volumetric Estimation of Chromic Acid by Means of Arsenious Acid in Alkaline Solution.—C. Reichard† utilizes the reducing action of arsenious acid upon chromic acid in alkaline solutions for the estimation of chromic acid, the method being especially adapted to the analysis of the lead chromates and other heavy metals. A solution of arsenious acid in 10% solution of sodium hydrate is standardized by titration with iodine or potassium permanganate. A measured quantity of this standard solution is added to the alkaline solution containing the chromic acid to be determined, the mixture boiled for some time and the excess of arsenious acid titrated back with iodine or potassium permanganate.

Chrome-Tanned Leather.—W. Eitner‡ points out that chrome-tanned leather is better adapted than any other tanned material to certain technical purposes, such as the manufacture of hose to be used with hot liquids, high speed belts, etc., by reason of its insolubility and its superior heat resisting properties. The author ascribes the high power of resisting external influences which this material possesses to the fact that in chrome tanning a more thorough penetration of the tanning substance into the hide is obtained than is possible with vegetable tanning.

Electric Reduction of Chromium.—Emil Vielhomme has patented§ a process for producing ferrochromium in the electric furnace. Chromite is treated with a suitable flux—kaolin, lime, fluorspar, etc., and the action of the electric current is continued after complete reduction and fusion until the iron is partially or entirely volatilized. The boiling point of chromium being higher, the product becomes richer in chromium and poorer in iron. The flux not only yields a fusible slag but furnishes a medium which moderately resists the passage of the electric current, allowing easy regulation and the final attainment of a high temperature. Also by its partial volatilization the iron vapors are removed. The charge consists of chromite containing oxides of chromium, magnesium, calcium, aluminum and silicon and coke or other carbonaceous material. It is stated that 22 lb. of lime, sand, kaolin and fluorspar are used per 100 lb. of chromite treated.

* *Zeitschrift fuer Angewandte Chemie*, 1900, p. 1147.
† *Chemiker Zeitung*, 1900, 563.
‡ *Der Gerber*, 26, 615.
§ United States Patent No. 648,119, April 24, 1900.

CLAY.

THERE has been a healthy growth in this industry during 1900, and production and prices have been well sustained in most of the important clay producing States. The consolidation of manufacturing interests, which was such a pronounced feature of the preceding year, has undoubtedly tended to restrict competition and maintain prices at a profitable figure. Whether these combinations will ultimately prove successful from a financial standpoint is an important question that still remains unsettled. In this connection it is to be noted that the field is one which admits the rapid development of competing factors, it being practically impossible to control the clay resources of even a limited locality.

The production of clay and clay materials in the United States is summarized in the following table:

SUMMARY OF PRODUCTION OF BRICK AND CLAY WARES IN 1899 AND 1900.

Kind.	1899.			1900.		
	No. of M.	Value.	Per M.	No. of M.	Value.	Per M.
Common brick	7,172,262	$37,642,105	$5·25	7,500,868	$39,195,913	$5·23
Front brick	386,448	3,281,717	8·49	455,771	4,601,686	10·09
Fire brick (*a*)	358,427	5,335,730	14·71	372,385	5,823,268	15·64
Paving and vitrified brick	653,005	5,637,571	8·63	724,370	6,503,442	8·97
Other clay building material (*b*)		5,714,734			5,530,369	
Sewer pipe and drain tile		*e* 8,242,771			*e* 8,550,000	
Crude clay, stoneware and misc. man'f'res (*c*)		*e* 8,200,000			*e* 8,500,000	
Totals		$74,054,628			$78,704,678	

(*a*) Not including silica brick. (*b*) Including terra cotta lumber, hollow building tile or blocks, roofing tile, floor tile and all other clay building material. (*c*) Including the value of common stoneware and various miscellaneous clay manufactures and crude clay used in pottery, for laying fire brick, in paper making, as burnt clay railway ballast, for the manufacture of gas retorts, glass pots, zinc retorts, etc. (*e*) Estimated.

The collection of these statistics is attended with many difficulties. In no other branch of the mineral industry except that of stone is the number of producers so large and so widely distributed. Most of them operate on a small scale, and as but little outlay of time and capital is required to open a brickyard, its abandonment is of no serious consideration. The list of producers consequently is subject to continuous revision. A further difficulty arises from the fact that some concerns do not keep any records of their work, and are therefore not in position to furnish accurate reports.

PRODUCTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1899. (IN THOUSANDS.)

States.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.		Paving Brick.		Other Clay Building Material.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.
Alabama (e)	57,000	$313,500	1,400	$16,800	7,000	$154,000	3,000	$45,000	$1,000
Arizona	10,450	72,120	125	1,750					
Arkansas	42,466	302,375	4,000	50,000					
California	a 125,950	a 754,730	e 3,000	e 66,000	e 500	e 10,000			
Colorado	35,068	245,476	11,652	97,667	3,503	71,833	6,125	60,250	43,000
Connecticut	104,561	505,325	5,023	47,300					57,327
Delaware(e)	12,500	87,500	250	2,250			40	400	
Dist. of Columbia	69,020	500,395	230	3,728			e 150	1,500	
Florida	38,157	209,477							
Georgia	145,000	580,000	17,558	307,649	2,200	26,400			e 60,000
Idaho	6,205	53,315							
Illinois	587,072	3,110,802	16,267	134,328	8,625	90,590	e 125,000	1,012,500	e 775,000
Indiana	437,206	2,615,224	7,334	30,382	9,364	154,582	e 45,000	270,000	e 375,000
Iowa (e)	200,000	950,500	8,500	771,400	880	8,800	40,000	320,000	25,000
Kansas (e)	45,000	283,500	7,000	56,000	650	5,500	30,000	247,500	
Kentucky	96,263	505,875	6,084	30,420	25,844	282,930	2,575	13,300	125,000
Louisiana	100,068	431,842	e 5,000	e 45,000			5,500	27,000	e 2,000
Maine	113,471	621,240	1,216	13,675			100	600	
Maryland (e)	140,000	714,000	5,500	60,500	7,000	84,000	6,000	54,000	53,499
Massachusetts	255,611	1,374,873	1,544	32,947	5,400	190,000			65,000
Michigan	178,000	729,800	16,500	99,000			3,500	38,500	e 7,000
Minnesota	155,608	856,867	12,050	80,600					37,000
Mississippi	25,220	163,832	2,140	10,554					
Missouri	228,062	698,417	21,474	76,820	e 15,000	e 180,000	e 30,000	e 300,000	e 275,000
Montana (b)	32,340	199,575	859	23,440	2,022	54,204	350	13,700	
Nebraska	115,296	738,840					5,000	37,500	
New Hampshire	69,000	356,250	875	8,750	1,500	30,000			
New Jersey (e)	375,000	1,737,500	37,000	603,000	30,000	690,000	250	3,500	2,200,000
New Mexico	2,128	14,231	1,333	10,640	266	2,793			
New York	1,221,398	5,865,115	32,097	264,276	e 20,000	400,000	e 30,000	e 360,000	e 675,000
North Carolina	75,830	303,320	e 950	8,550	800	7,200			e 1,500
North Dakota	23,220	141,750	3,780	37,800			1,425	38,262	250
Ohio	570,678	3,323,571	61,883	653,855	97,773	1,189,779	200,380	1,847,780	374,718
Oklahoma (c)	2,889	16,983							
Oregon	16,254	101,416	1,022	27,139	140	1,680			
Pennsylvania	760,206	4,330,618	71,823	1,073,418	115,236	1,651,596	76,809	916,266	e 500,000
Rhode Island (e)	e 35,000	e 192,500	1,200	10,400			4,500	54,000	15,000
South Carolina	76,550	331,036	1,316	8,360	600	6,000	500	2,500	
South Dakota	5,200	32,800	400	4,400			10	120	
Tennessee	119,161	639,881	3,980	30,500	110	4,240	10,532	e 150,160	1,600
Texas	126,644	602,507	2,922	22,702	714	26,404			840
Utah	27,295	191,625	2,000	16,000					
Vermont (b)	27,840	125,360							
Virginia	99,522	555,592	2,246	104,477			1,219	13,167	e 40,000
Washington	29,480	205,800					40	560	
West Virginia (e)	28,000	154,000			300	3,600	25,000	222,500	5,000
Wisconsin	124,923	795,750	4,915	33,240					
Wyoming (e)	450	3,600							
Totals	7,172,262	$37,642,105	386,448	$3,281,717	358,427	$5,335,730	653,005	$5,637,571	$5,714,734

(a) Statistics reported by the California State Mineralogist. (b) Statistics collected in co-operation with the Montana Geological Survey. (c) Includes production of Indian Territory. (e) Estimated.

The production of brick and clay building material by States in 1899 and 1900 is presented in the above tables. In these tables the columns "common brick" include only the ordinary red brick that is used generally in building. Under "front brick" we have grouped pressed brick of all colors. Under "fire brick," however, only what is properly termed alumina brick is included. Such silica brick as Dinas brick, which is also properly called "fire brick" or "refractory brick" being omitted, because it is not a clay product. "Other clay material" includes fancy or ornamental and enameled brick, roofing tile, terra cotta, terra cotta lumber, floor tile, hollow building blocks, etc. All the clay material other than brick, which is now used so extensively in the construction of fireproof buildings is included under this classification. In the preparation of the table for 1899 the statistics collected by the State Geological Surveys have been used so

PRODUCTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1900. (IN THOUSANDS.)

States.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.		Paving Brick.		Other Clay Building Material.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.
Alabama	50,700	$294,060			e 6,760	$141,960			e $1,000
Arizona (e)	10,000	70,000	125	$1,750					
Arkansas	45,000	281,250	e 5,000	55,000					
California (e)	130,000	650,000	3,000	60,000					
Colorado	42,520	245,980	21,296	222,818	2,092	35,563	1,338	$13,381	754
Connecticut	141,381	709,403	7,000	63,000					65,000
Delaware	13,650	87,019	2,625	26,250					
Dist. of Columbia	90,000	760,000	3,150	56,400					
Florida	35,120	210,000							
Georgia	199,043	977,960	4,874	58,469	e 2,200	26,400	4,861	17,043	e 65,000
Idaho	18,107	129,804							
Illinois	476,350	2,581,817	17,003	87,856	9,519	81,078	190,156	1,639,191	784,743
Indian Territory	4,000	20,000	500	5,000					
Indiana	392,320	2,126,374	15,123	138,351	3,762	37,622	65,921	662,321	e 350,000
Iowa	244,804	1,494,893	11,409	101,287	206	2,361	30,002	220,455	60,528
Kansas (e)	50,000	300,000	8,000	60,000	700	6,300	30,000	240,000	
Kentucky	128,641	666,456	6,500	39,000	28,000	290,000	3,000	18,000	130,000
Louisiana	114,285	338,915	9,600	76,800			5,000	30,000	5,000
Maine	115,000	618,700	2,325	18,800			150	1,200	
Maryland	233,517	1,451,479	9,614	204,791	6,495	101,888	144	1,299	60,000
Massachusetts	305,415	1,573,478	75,850	918,700	6,000	95,000			75,000
Michigan	204,081	960,254	3,858	26,758			4,000	36,000	e 8,000
Minnesota	211,623	1,074,715	9,234	92,525	114	2,286			31,544
Mississippi	48,164	263,110	712	5,435			5,176	31,059	
Missouri	225,000	867,500	20,000	125,000	14,594	179,607	24,721	197,903	e 300,000
Montana	43,013	240,444	78	1,163	2,000	50,000	350	15,000	
Nebraska	103,512	643,227	3,810	30,476			5,714	40,524	
New Hampshire	63,484	335,273	6,490	67,850	1,180	23,600	944	8,496	
New Jersey	355,047	1,485,028	35,000	600,000	30,000	600,000	300	3,000	e 2,000,000
New Mexico	2,000	14,000	1,300	10,400	250	2,500			
New York	1,120,000	4,849,600	30,000	240,000	e 20,000	400,000	35,000	420,000	650,000
North Carolina	102,060	516,537	206	2,057	57	1,143	100	800	1,500
North Dakota	42,196	257,550	1,083	11,375	350	6,300	1,500	35,000	300
Ohio	522,949	3,032,783	66,359	129,896	105,779	2,114,582	e 200,000	1,800,000	e 375,000
Oklahoma	12,581	84,279							
Oregon	14,732	104,539	183	5,238	5	84			
Pennsylvania	797,681	5,246,237	61,998	663,946	100,774	1,606,213	68,887	589,881	e 500,000
Rhode Island (e)	40,000	210,000	1,500	13,500			5,000	45,000	15,000
South Carolina	142,837	652,781	904	9,047	e 600	6,000	500	2,500	
South Dakota	16,286	131,571	157	5,143			150	1,500	
Tennessee	126,768	650,983	3,048	30,479	48	481	e 12,000	170,000	e 2,000
Texas	141,340	838,032	5,799	63,143	500	7,500	2,767	24,800	
Utah	40,903	227,645	5,607	60,487					
Vermont	42,257	194,827	14,571	65,571					
Virginia	77,398	430,017	1,290	15,382			1,346	12,789	e 45,000
Washington	61,234	471,682	3,400	68,000			350	6,300	
West Virginia	23,012	116,417	1,750	21,000	e 400	4,800	e 25,000	220,000	e 5,000
Wisconsin	122,727	755,794	4,460	33,630					
Wyoming	e 300	2,700							
Totals	7,500,868	$39,195,913	455,771	$4,601,686	372,385	$5,823,268	724,370	$6,503,442	$5,530,369

(e) Estimated.

far as possible, but the figures for 1900 have been collected entirely at this office as the various State reports were not available at the time of publication. There is apt to be a variation in the results of any statistical inquiry concerning this subject from year to year and State to State, not only between the results of two statisticians for the same year, but also in the results of the same statisticians in different years, owing to uncertainty as to the classification of certain products, not only by the statisticians but also by the producers themselves in making their returns. For example, there is no sharp dividing line between front brick and fire brick; pressed brick used in the construction of houses are sometimes manufactured of fire clay by the same concerns that make brick for furnace construction.

District of Columbia.—The Washington market is supplied largely by local

yards, which sell through the Standard Brick Co. Business in 1900 was profitable and of good volume.

Illinois.—This is one of the leading States in the manufacture of clay building material, the largest center being Chicago, where some 40 plants are located. The demand in 1900 was injured by the labor troubles which prevailed throughout most of the year. It is estimated that the consumption of brick amounted to 275,000,000 or 50,000,000 less than in the preceding year.

Massachusetts.—The New England Brick Co. has taken over a large number of yards in Maine, New Hampshire, Massachusetts and eastern New York with a view of controlling the Boston market.

Missouri.—Extensive deposits of clays suitable for the manufacture of china and stone ware, terra cotta, fireproofing, sewer pipe and brick are found within the boundaries of this State. The industry has attained extensive development around St. Louis, which furnishes a large market for building materials. The consumption of brick in this city in 1900 is estimated at 70,000,000, which is considerably less than the average.

New York.—The output of building brick was somewhat less than 1899, but still remains the largest among the States. The industry is spread over a wide area, but the most important districts are in the vicinity of the large cities. The Hudson River Valley clays are the basis of extensive manufacture, there being more than 100 producers in this region. The New York market in 1900 was greatly overstocked and low prices ruled throughout the year. Quotations for tide water brick (Haverstraw and Newburgh) ranged from $3·875 in May to $5 in December, or about $1 below those of 1899.

Ohio.—At Cincinnati the brickyards found a ready sale for their output in the local market, and business was good also at Cleveland and Canton. The pottery industry was particularly prosperous.

Pennsylvania.—The output of the 90 yards located at Philadelphia was about 240,000,000, or 40,000,000 more than in 1899. At Pittsburg and other cities in western Pennsylvania there was unusual activity in the industry, the demand for fire brick being particularly heavy. The American Clay Manufacturing Co. is the largest operator in this region.

Clay and Its Manufacture into Brick and Tile.

By Heinrich Ries.

There are probably few raw materials concerning whose properties more theorizing has been done, or more written, than clay, and yet withal there still remain many points that need proper explanation. One reason for this lies no doubt in the fact that the characters which influence its unique properties are in themselves microscopic, and liable to be passed over in any investigation. Another reason is that the true nature of clay has been but little understood for many years, chiefly because it has been customary to attack all problems connected with this material from a chemical standpoint only; this, however, was found to be fallacious, for it soon became evident that many clays of almost absolute agreement in their chemical composition were widely divergent in their general behavior otherwise, a fact that calls not only for a consideration of the chemical properties in the working of clays, but for the physical features as well.

The term "clay" means comparatively little in a mineralogical or chemical sense, but it indicates much in a physical one. In defining it, however, all three should be included. Clay may be defined as a fine-grained mixture of the mineral kaolinite (the hydrated aluminum silicate) with fragments of other minerals, as silicates, oxides and hydrates, the mass possessing plasticity when wet and becoming rock hard when burned at a red heat or beyond. The mineral kaolinite results usually from the decomposition of feldspar. It is a hydrated aluminum silicate possessing the formula Al_2O_3, $2SiO_2$, $2H_2O$, and when heated above redness the chemically combined water is expelled. While the percentage of kaolinite, or clay substance as it is also called, is extremely variable in clays, at the same time it stands in no direct relation to the plasticity, but rather indirectly to it. Clays which have been heated sufficiently high to lose their combined water will not become plastic again, still the most plastic clays are not those containing the highest percentage of kaolinite or clay substance. Thus, for instance, of two samples of clay (*North Carolina Geological Survey Bulletin, No. 13, p. 33*) one from Roanoke Rapids, N. C., was highly plastic and contained 16·09% Al_2O_3, while the other, a washed kaolin of lean character from Dillsboro, N. C., had 40·61% Al_2O_3. The former represents approximately 42·28% of clay substance, and the latter 96·81%.

Since the chemical and physical properties of clay have an important bearing on their applications and methods of treatment, it may be well to discuss them first, in some detail, in order that the facts thus gained can be more intelligently applied later. By the chemical properties, we understand those characters which are directly or largely dependent on the chemical composition. This includes fusibility, color in burning and fire shrinkage. The physical properties are those dependent on the structure of the mass and include plasticity, shrinkage, tensile strength, fusibility and slaking. From this enumeration it will be seen that certain characters are influenced by both the chemical and physical action. Fusibility, for example, while largely influenced by chemical composition is also affected by the size of the grain. Shrinkage is partly

the result of physical structure, but fire shrinkage especially is also governed by the chemical composition.

Chemical Properties.—The number of common elements which a clay may contain is very great, and the presence of rarer ones has been noted. The elements usually present are few in number and are those determined in the ordinary chemical analysis, which shows their existence in the clay, but not always their method of combination. The common constituents of clay are silica, alumina, ferric or ferrous oxide, lime, magnesia, alkalies and combined water. Organic matter may be present, but is seldom determined separately, being classed with water and called the "loss on ignition." The effect of these constituents is as follows:

Alkalies.—These include potash, soda, ammonia and in rare cases lithia. Ammonia is a common constituent of many clays and is often noticeable on account of its odor, but so far as known it exerts but little influence on the properties of the clay in manufacture.

Potash and soda, being non-volatile except at high temperatures, must be given serious consideration. Few clays lack them, and their combined amount varies from 1% or less in some refractory or other high-grade clays to 5 or even 6% in common brick materials. This variation is shown by the following average of many analyses:

	Minimum. %	Maximum. %	Average. %
Brick clays	0·17	15·32	2·768
Pottery clays	0·52	7·11	2·060
Fire clays	0·048	12·28	1·460

Potash and soda are derived mainly from the presence in the clay of undecomposed feldspar grains and orthoclase, the common feldspar, containing 17% K_2O may often be present in large amounts. Mica also may be a source of potash, and its bright, shining scales are much more easily seen in the clay than the grains of feldspar. The variety muscovite contains 12% K_2O. Alkalies, generally speaking, are fluxes, and they show variable strength, depending on their parent mineral. Feldspar fuses at a comparatively low temperature (about 2,300° F.) and fluxes easily with other ingredients of the clay. Muscovite, the potash mica, on the other hand, is very refractory, and is unaffected by a temperature of 2,550° F. It does not flux with other ingredients of a clay except at a much higher temperature than feldspar; therefore, if we wish to add fluxing material to a clay mixture in order to cause it to melt at a lower temperature, we must see that it is added in a form that will do the most good. In the manufacture of many medium or high-grade clay products, the alkalies are added as feldspar to serve as a flux and bond, which binds the body together in a firm and often impervious mass.

Iron Compounds.—These are even more widely distributed than alkalies. They serve not only as fluxes but also as coloring agents, and changes in the method of manipulation in burning will bring out a variety of effects. Their usual occurrence in clay is in the form of oxide or as a constituent of silicate minerals. Many clays which in their primitive state do not contain much iron

may have it introduced by a subsequent infiltration of ferruginous waters. It may also be added artificially.

As a flux iron salts tend to promote the fusion of clay particles when the material is heated, the action increasing with the amount of iron present, and perhaps with the degree of oxidation, ferrous compounds being more fusible than ferric ones. When fusion does occur as a result of fluxing action a new and complex ferrous silicate is formed. In fact, ferric oxide at a high temperature appears to give up some of its oxygen and become changed to ferrous oxide. It is not quite as powerful a flux as the alkalies.

As a coloring agent no substance exerts so intense an effect on either raw or burned clays as does iron. In the raw clay it may produce yellow, brown (limonite) or red (hematite) tints and in the burned clay, chiefly red but also partly buff or bluish black. The evenness of the tint depends on the state of division and the regularity of the distribution of the iron salts. The coloration of the raw material may have a double bearing. In the first place, it points out approximately the relative amount of iron which the material contains and therefore gives a clue to its refractoriness and also to the color when burned, for the more highly the raw material is colored, the more intense its color is apt to be after firing. In this connection the fact must be considered that a given quantity of iron oxide will color a sandy clay much more than a highly plastic one lacking sand. If the clay is colored by iron oxide, hematite is preferable to limonite, for the latter contains combined water which has to be driven off during the burning. In this operation, if sufficient air enters and the effect of the fire is oxidizing, all forms of iron will change to the ferric condition and color the clay red, this color being maintained until vitrification is accomplished or perhaps even beyond, whereupon the formation of ferrous salts begins and the red passes over into purple and bluish black. The same effect may be hastened artificially, and, in fact, cannot be prevented in high temperature kilns.

Iron may, however, color the burned clay buff under two conditions: (1) When the clay contains at least three times as much lime as iron (see lime), and (2) when there is not over 2 or 3% Fe_2O_3 in the clay. The former is a characteristic of marly clays, and the latter of semi-fire clays.

The effect of iron on shrinkage is one to which little attention has been given, and yet it should not be neglected. Clays absorb variable amounts of moisture in being worked up for molding, and while this is essentially due to the structure of the material still limonite when present seems to increase the absorptive power. The percentage of ferric oxide varies considerably in different clays, the average for a number of kaolin analyses being 1·27%, and for a series of brick clays 5·311%.

Lime.—This component is also widespread and may act in a similar manner to iron. As a flux its action depends on its combination. As silicate it is good, but in the form of carbonate (either calcite or dolomite) it is bad. Unfortunately it is found as a carbonate in many clays, a combination that is easily detected by its effervescence with acid.* An excess of lime carbonate, 30 or 40%, causes it to pass into marl, in which form it has greater value for cement

* The dolomite effervesces only with warm acid.

than for clay products. A highly calcareous clay is not only undesirable on account of its easy fusibility, but also on account of rapidity of fusion. (See fusibility.)

As far as known, lime does not color green clays, but causes far-reaching effects at times in its bleaching action by counteracting the effect of iron oxide and producing a buff product. This is most noticeable when lime is to iron oxide as 3 to 1, but the effect is already noticeable with a ratio of 1·5 to 1. Therefore the same color is obtained with excess of lime or lack of iron, but the hardness of the product differs, as the calcareous clay brick will be soft, while the one low in iron may be very hard and resistant to weathering influences. Whenever buff products are desired it is consequently far more desirable to use a semi-refractory clay than a calcareous one.

Seger found some years ago that calcareous clays possess a lower absorptive power than other kinds, and where an ordinary clay free from lime might require 28 or 30% of water to develop its maximum plasticity, the calcareous clay would need only 20 to 25%. This may possibly be due to the fact that the lime causes a flocculation of the clay particles, which would increase the size of the pores in the material as well as diminish their number, thereby decreasing the water capacity. It is perhaps well that calcareous clays do take up less water, for otherwise the driving off of this together with the carbonic dioxide in burning would leave the burned material in an excessively porous condition unless burned very hard. If it is necessary to use a calcareous clay in the manufacture of clay products, care should be taken that the lime is evenly distributed and finely divided, for it does the least harm under these conditions. Many clays contain lime in the form of pebbles or concretions. When in the latter form they are known to the clay worker as "clay dogs" or "clay stones." These pebbles and lumps are undesirable and should be removed either by screening after the clay is dry or by crushing to a state of fine division.

Some clays and also shales contain lime in the form of gypsum, the hydrated calcium sulphate. This compound contains two volatile elements: the water which is driven off during the process of water smoking and the sulphuric acid, which passes off after a temperature of redness has been attained. The former is not apt to cause trouble, but the latter may, especially if the clay has already begun to soften, when the escaping gas, if present in large quantity, will produce blisters on the surface of the ware. Few clays contain gypsum in large quantities, but when present it is often easily recognizable by the fact that it occurs in the form of transparent plates of a pearly luster and of a softness easily scratched with the fingernail.

Magnesia.—This compound occurs in many clays, but is seldom present in large amount. An exception to this statement must be made in the case of many lake clays found in Michigan in which the magnesia appears to have the same effect as lime. It may occur in the clay as dolomite, as a constituent of biotite mica or other dark silicate minerals, or as the simple magnesium carbonate, magnesite.

Silica.—This compound is one of the most important of the constituents of clay that is to be considered but its properties are sometimes misunderstood

because the term "silica" is not always applied in its proper sense. Many consider it synonymous with sand, but this is erroneous, for, while the sand grains in many cases are composed of quartz, they may at times also include other mineral species whose action when the clay is heated is quite different from the behavior of quartz.

There are three occurrences of silica in clays; *viz.:* 1. That which is derived from quartz. 2. That which is combined with alumina in the mineral kaolinite. 3. That which is contained in silicate minerals, as feldspar, hornblende, garnet, mica, etc. In ordinary chemical analyses we often find the first and third grouped together as sand, which is correct, but on the other hand they are sometimes improperly termed free silica.

When a clay is heated sufficiently to start a fusion of some of the particles, chemical reactions between some or all of them begin; the silica tends to resist fusion until a comparatively high temperature is reached and consequently it serves as a refractory element in the clay. Up to a certain temperature its power as a refractory element will be the greater, the smaller the quantity of fluxing impurities, as iron, lime, magnesia and alkalies that is present in the clay. It is quite natural that during the early stages of fusion the melting of some of these substances containing bases exerts a slight amount of fluxing action on the surface of the silica grains, but these being refractory will not soften, and consequently this union will progress but slowly. If the clay is very low in fluxing impurities and contains alumina and silica as its two chief elements, the refractory nature of the silica up to a high temperature will assert itself more strongly, but above that temperature, which is probably about 2,800° F., the silica will flux with the alumina; therefore, in clays which are to be used for very refractory wares an excess of silica is undesirable. Many fire brick manufacturers do not seem to recognize this point.

The term sand includes the coarser grains of clay or those which tend to reduce its plastic qualities. They may show a wide range mineralogically and may include not only refractory grains of quartz, but also easily fusible grains of feldspar. Their influence, therefore, on the properties of the clay may be both physical and chemical. They may act physically in tending to decrease the plasticity, this effect being the more noticeable the greater the percentage of sand grains and the larger their size. They may also affect the absorptive power of the clay for water, generally tending to decrease it, although there are exceptions in the case of clays that contain sand grains of great fineness, the effect then being to increase the number of the pores and to decrease their size, thus augmenting their capillary power. Sand grains decrease the shrinkage of the clay both in drying and burning, in effect inversely as the size and number of the grains. Chemically, sand may act as a fluxing agent. In a clay that contains sand grains of different minerals, these grains will serve as refractory elements and hold the form of the clay in burning until the fusion point of any one of them is reached, whereupon the fusible ones serve as fluxes to bind the clay mass together. The intensity of this action will increase with the number of the fusible grains in the sand and with their fineness of division.

Titanium.—It is probable that titanium is one of the most widely distributed

minerals in clay, but owing to the small quantity of it usually present and the general lack of knowledge concerning its effects it is seldom looked for and less often suspected. In the light of our present knowledge titanium is never present in any clays thus far analyzed, in quantities sufficient to affect their properties or their commercial uses. It is usually looked upon as an inert impurity, and while this is probably true to a certain extent, yet at the same time we should not fail to overlook its possible effects when present in appreciable amounts. From the experiments of Prof. Seger we know that it acts somewhat similarly to silica in the burning of the clay; *i.e.*, as a fluxing agent at high temperatures. His experiments have shown that 6·65% TiO_2 added to a high-grade kaolin was sufficient to cause a dark blue coloration and vitrification at a temperature somewhat above the melting point of wrought iron, while 13·3% TiO_2 gave a blue enamel when heated to the same temperature. For some reason or other chemists have determined titanium more often in fire clays than in other varieties, and an examination of any series of analyses will show quite a wide variation in many clays, the percentage of TiO_2 being often under 1%, while in exceptional cases it is found to reach 3 or even 3·5%.

Organic Matter in Clays.—Organic matter is commonly found in clays either as lignite or more often in the form of very fine shreds and fragments. It is wide reaching in its effects, for it influences not only the color of green clay but also its absorptive power, plasticity, tensile strength and weathering properties. Many surface clays contain organic matter in the form of plant roots. These usually exert little effect other than to aid in the percolation of surface waters, and it is usually in the clays of the Cretaceous, Tertiary and Carboniferous groups that we find it most widely and evenly distributed. Clays colored by organic matter are usually gray, bluish gray, or black, depending upon the quantity present. When the clay is burned the plant tissue will usually burn off entirely at bright redness unless the clay is heated too quickly, when the pores are closed up suddenly and prevent the combustion of some of the organic material, which causes the interior of the ware to become dark-colored. This is especially true of very plastic clays. Clays colored by organic matter in their green condition and free from iron do not burn to a white tint, but it not infrequently happens that organic matter overcomes the presence of iron oxide in the clay, and the material, instead of burning white, burns red at a temperature above that at which organic matter is destroyed; below that temperature the presence of the organic matter might tend to keep the iron in a reduced condition. Organic matter if finely divided and not in excess tends to increase the plasticity of the clay and to raise its tensile strength, but high plasticity does not always indicate the presence of a large quantity of organic matter. Furthermore, organic matter tends to increase the absorptive power as already mentioned in that it absorbs a certain quantity of water itself in addition to that absorbed by the clay. This additional amount of water must of course be expelled in the drying and burning of the material, and unless these processes are carried on very slowly and with great care, a cracking of the ware may result.

In the preparation of clays by weathering, organic matter often exerts a very

beneficial effect because of its slow oxidation; the escape of the carbonic acid gas thus formed aiding in the decomposition of the clay particles.

Water.—This constituent occurs in two forms—moisture and chemically combined water. Moisture may be as little as 0·5% in air dried clays and may reach 30 or 40% in those freshly taken from the bank. Air drying expels most of the moisture in a clay and is accompanied by the air shrinkage, which may amount to from 2 to 12%, depending on the plasticity of the clay and the amount of sand that it contains. Combined water is present in clays in various amounts. Some contain as little as 4% H_2O, while pure kaolin has nearly 14% H_2O. It is expelled from the clay at red heat only, its expulsion being accompanied by a decrease in volume known as "fire shrinkage." As is mentioned elsewhere in this paper, fire shrinkage is also affected by the expulsion from the clay of organic matter, carbon dioxide and sulphuric acid gases.

Fusibility of Clays.—The fusibility of clay is influenced primarily by the amount of fluxing impurities present, and, knowing this, it is often possible to alter the refractoriness or fusibility of a clay so as to bring its behavior under heat within the proper limits. The fusibility of clays depends upon (1) the amount of fluxes, (2) the size of grain of the refractory and non-refractory constituents, (3) the condition of the kiln, (4) the manner of the distribution of the fluxing particles, and (5) the kind and combination of the fluxes.

With regard to (1)—the amount of fluxes—it has already been mentioned that lime, magnesia, iron oxide and alkalies tend to act as a flux, thereby lowering the fusing point of a clay, and, while this fluxing action increases with the total quantity of fluxes, it also appears as if some exercised a greater fluxing power than others. This is claimed for alkalies, and, while it seems probable, still it has not been actually proven. The quality or combination of the fluxing elements undoubtedly is of vital importance, it being probably best to have the fluxing bases present as a constituent of silicate minerals. Thus, for example, lime if contained in clay as a carbonate is a powerful fluxing material and causes the clay to soften most rapidly under the action of heat, but if it is in the clay as an element of feldspar the clay fuses very slowly. Potash when an ingredient of feldspar is an active flux, but if imprisoned in mica it resists fusion until brought to a temperature of not less than 2,400° F. This mica when heated alone is nearly as refractory as kaolinite.

(2) *The Size of Grain.*—Since the fusion of a mineral grain begins on the surface and works inwardly, the entire mass of fluxing grains in a clay will take a longer time to become soft when they are large than when they are in a very finely divided condition. For the same reason, the relative size of the fluxing and non-fluxing grains in a clay governs the ease and rate at which it softens under the action of heat.

(3) *The Condition of the Kiln.*—Manufacturers do not always realize the difference that exists between the fusing points of high and low salts of a compound. Iron compounds when in the ferric or higher stage of oxidization may require 200° F. more heat to fuse them than when in the ferrous or lower stage of oxidization. The change therefore in the method of firing a kiln, such as overloading grates with coal or shutting off the air supply in some other way

may bring about a reducing action and cause vitrification of the ware before the process of burning has been completed. The condition of the interior of the kiln may sometimes be judged by the character of the smoke coming out of it and also by means of Orsat's apparatus for the analysis of gases.

(4) *Distribution of the Fluxing Particles.*—Fluxes, whatever their character, will exert more effect if evenly and finely distributed than if present in lumps or patches. The effect of the latter is simply to induce fusion in its immediate neighborhood. This effect is seen in the Pompeiian brick now so extensively used, the speckled appearance being caused by the local fluxing action of manganese grains that have been added to the clay during the process of tempering.

(5) *Kind and Combination of Fluxes.*—When clay is subjected to a rising temperature, one of the first effects is the evaporation of the last traces of mechanically combined water. In the manufacture of clay products this change is spoken of as water smoking. After this effect very little change takes place in the volume of the clay until the temperature above redness is reached and the particles begin to soften under the action of heat. The softening of the clay as a result of fusion takes place very slowly, the change being more gradual the greater the refractoriness of the material, yet while the softening process is a gradual one, at the same time it is possible to distinguish three stages in it. The first stage is where the individual grains have wholly or in part softened sufficiently to make the clay mass stick together, while few of the grains have lost their individuality and the mass as a whole is usually sufficiently hard to resist slightly the scratching with a knife point. This condition is known as the stage of incipient fusion. With a further rise in temperature the grains not only become softer but others not yet affected also begin to soften, this change being so great that the individual grains crush out of shape and pack themselves together into a more or less impervious mass. This is known as the stage of vitrification. A still further rise in the temperature brings us to a point at which the grains have wholly or in part softened to such a degree that the mass no longer holds itself together, but flows, becoming viscous under the action of heat. This fuel stage is known as the condition of viscosity. The practical value of distinguishing these three stages is that the greater the difference between the temperatures of incipient fusion and viscosity the easier it will be to raise the temperature of the kiln to the temperature of vitrification without the danger of running into that of viscosity. This is important, as kilns can seldom be controlled within a range of a few degrees.

Those clays that contain a high percentage of calcium carbonate show the least difference between incipient fusion and viscosity, one following the other sometimes within a range of 100° F. On the other hand, a clay low in lime has a range of perhaps 400° F., a fact of value in the production of vitrified wares, while in some fire clays which run low in all fluxes the difference may amount to 600° F., a condition especially necessary in the treatment of glass-pot clays.

Methods of Judging Temperature.—There are several different methods of judging or determining the temperature of a kiln, some being approximate while others are of extreme accuracy. Unfortunately the most accurate methods often involve the use of expensive apparatus and are consequently not to be considered

for use in works manufacturing low-grade clay wares. At the same time, the idea is growing among manufacturers that it is important to have some reliable means of judging the temperature of the kiln.

The old method and one still used was simply to judge the completion of the burning by the use of trial pieces without much regard to the actual temperature or to the conditions existing before that temperature was reached. These trial pieces are usually set in an accessible part of the kiln, and the burning is considered finished when the trial pieces show a certain degree of shrinkage or when the glaze which is sometimes on them is thoroughly melted. Another method for determining the burning, and one in use in common brickyards, is to determine the amount of "settle" in the kiln.

At the present time there are two reliable methods in use for determining the completion of the burning, its progress and the temperature of the kiln. These are the use of the thermo-electric pyrometer and Seger's pyramids. Le Chatelier's thermo-electric pyrometer depends upon the electric current generated by the heating of a thermopile, the latter consisting of two wires, the one of platinum and the other of 90% platinum and 10% rhodium, the two being twisted together at the end for the distance of 1 in., while the next foot or two is enclosed in a fire-clay tube so that when the couple is inserted into the furnace only the end which is held near the body whose temperature is to be measured will receive the full force of the heat. The two wires are connected with a galvanometer the deflection of whose needle increases with the temperature at the point of the further end of the wire couple. As at present put on the market the thermo-electric pyrometer costs about $180, and this, together with the delicacy of the galvanometer, has tended to restrict its use. It is not necessary, however, that the galvanometer should always be kept close to the kiln or kilns which are to be measured, and it is possible to have the recording instrument in a room some distance away, the only requirement being that the wire connecting the couple with the galvanometer should be always of the same length or if one of different length is used that proper allowance be made for the difference in resistance. This pyrometer is considered to be accurate to within 10° F. Its special advantages are that it determines the temperature of the kiln accurately; it can be read at any time, and with this can be determined by an automatic device if necessary whether the heat of the kiln is rising gradually or whether there have been fluctuations in the temperature; also, whether the temperature has risen gradually from beginning to end or whether it has for a time risen rapidly and then very slowly. This form of pyrometer is used at several works in Europe and in the United States and at several potteries and wall tile works, but its introduction into factories producing the lower grades of ware has not yet been attempted.

Seger's pyramids are small pyramids consisting of different mixtures of kaolin and fluxes which are so compounded that there shall be a constant difference between their fusing points. The series runs from ·022 up to 36. In numbers 1 to 20 there is a difference of 36° F. between their fusing points; those below this series have a difference of 54° F. between their fusing points. The theory of these pyramids is that a pyramid bends over as the temperature ap-

proaches its fusing point, and when this is reached the top touches the base. (See Fig. 1.) While therefore these pyramids show the temperature of the kiln in a general way, at the same time they show, more properly speaking, the effects of a given quantity of heat. Their advantages are that they are cheap, simple to use and form an easy means of regulating the burning of a kiln; on the other hand, their disadvantages are that they simply show the results and do not give any clue to the conditions that exist during the burning of the ware. A series of them might be used which by watching closely and noticing whether they bend over in regular succession would show that the temperature of the kiln was gradually rising, but there would be no means of indicating a temporary fall of temperature. For most practical purposes in the manufacture of the low-grade and medium-grade wares these cones are considered sufficiently accurate. They are used to a very large extent on the Continent of Europe, and although American manufacturers have been slow to take them up, there is hardly a State in the Union in which some of them are not used.

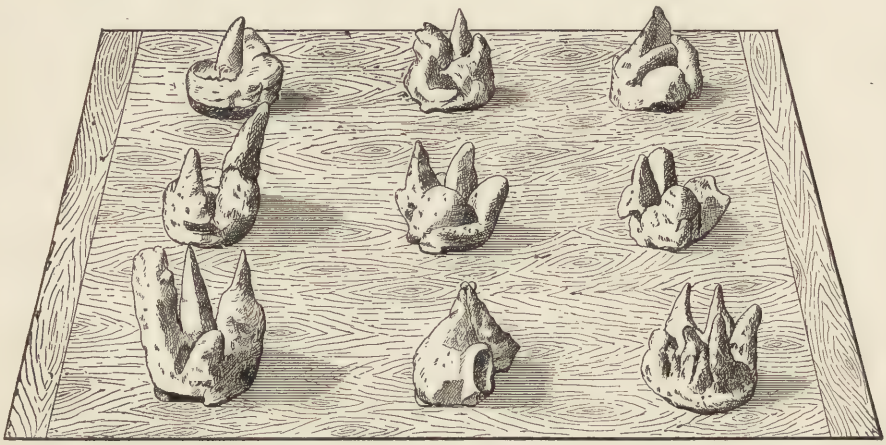


FIG. 1.—SEGER'S PYRAMIDS, SHOWING THE ACTION OF HIGH TEMPERATURE.

In actual practice they are placed in the kiln at a point where they can be watched through a peep-hole and are protected from the direct touch of the flame from the fuel. It is always well to put two or more cones in the kiln so that warning can be had not only of the approach of the desired temperature, but also, if possible, of the rapidity with which the temperature is rising. In order to determine the temperature of the kiln several cones of separate numbers are put in; for instance, ·05, 2 and 6. Suppose ·05 and 2 are turned over in the burning, but 6 is not affected, then the temperature of the kiln was between 2 and 6; the next time 3, 4 and 5 are put in and 3 and 4 may be fused but 5 remain unaffected, indicating that the temperature reached the fusion point of 4. The table on the following page gives the numbers of the cones, their composition and their fusing points in Centigrade and Fahrenheit degrees.

Tensile Strength.—It is noticeable that there exists a varying amount of cohesion between the particles of a clay both in its wet- and air-dried condition, some showing more resistance when pulled or broken apart than others. The

proper development of such a character is desirable, as is readily understood when consideration is taken of the fact that in the shrinkage of clays in drying stresses must be induced within the mass and that those clays whose particles cohere the best resist the strain better. The resistance which the clay mass offers to rupture is known as the tensile strength, and its variation can be best studied in the air-dried material. Indeed, it is while the clay is approaching

FUSION TEMPERATURES OF SEGER'S PYRAMIDS.

No. of Cone.	Composition.			Fusion point C.	Fusion point F.
022	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$		$2SiO_2$ $1B_2O_3$	590	1094
021	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}1Al_2O_3$	$2{\cdot}2SiO_2$ $1B_2O_3$	620	1148
020	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}2Al_2O_3$	$2{\cdot}4SiO_2$ $1B_2O_3$	650	1202
019	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}3Al_2O_3$	$2{\cdot}6SiO_2$ $1B_2O_3$	680	1256
018	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}4Al_2O_3$	$2{\cdot}8SiO_2$ $1B_2O_3$	710	1310
017	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}5Al_2O_3$	$3{\cdot}0SiO_2$ $1B_2O_3$	740	1364
016	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}55Al_2O_3$	$3{\cdot}1SiO_2$ $1B_2O_3$	770	1418
015	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}6Al_2O_3$	$3{\cdot}2SiO_2$ $1B_2O_3$	800	1472
014	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}65Al_2O_3$	$3{\cdot}3SiO_2$ $1B_2O_3$	830	1526
013	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}7Al_2O_3$	$3{\cdot}4SiO_2$ $1B_2O_3$	860	1580
012	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0.75Al_2C_3$	$3{\cdot}5SiO_2$ $1B_2O_3$	890	1634
011	$0{\cdot}5Na_2O$ $0{\cdot}5PbO$	$0{\cdot}8Al_2O_3$	$3{\cdot}6SiO_2$ $1B_2O_3$	920	1688
010	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}5SiO_2$ $0{\cdot}50B_2O_3$	950	1742
09	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}55SiO_2$ $0{\cdot}45B_2O_3$	970	1778
08	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}60SiO_2$ $0{\cdot}46B_2O_3$	990	1814
07	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}2Al_2O_3$	$3{\cdot}65SiO_2$ $0{\cdot}35B_2O_3$	1010	1850
06	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}70SiO_2$ $0{\cdot}30B_2O_3$	1030	1886
05	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}2Al_2O_3$	$3{\cdot}75SiO_2$ $0{\cdot}25B_2O_3$	1050	1922
04	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}80SiO_2$ $0{\cdot}20B_2O_3$	1070	1958
03	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}85SiO_2$ $0{\cdot}15B_2O_3$	1090	1994
02	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}90SiO_2$ $0{\cdot}10B_2O_3$	1110	2030
01	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$3{\cdot}95SiO_2$ $0{\cdot}05B_2O_3$	1130	2066
1	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}3Al_2O_3$	$4SiO_2$	1150	2102
2	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}2Fe_2O_3$ $0{\cdot}4Al_2O_3$	$4SiO_2$	1170	2138
3	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}05Fe_2O_3$ $0{\cdot}45Al_2O_3$	$4SiO_2$	1190*	2174
4	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}5Al_2O_3$, $4SiO_2$		1210	2210
5	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}5Al_2O_3$, $5SiO_2$		1230	2246
6	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}6Al_2O_3$, $6SiO_2$		1250	2282
7	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}7Al_2O_3$, $7SiO_2$		1270	2318
8	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}8Al_2O_3$, $8SiO_2$		1290	2354
9	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$0{\cdot}9Al_2O_3$, $9SiO_2$		1310	2390
10	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$1{\cdot}0Al_2O_3$, $10SiO_2$		1330	2426
11	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$1{\cdot}2Al_2O_3$, $12SiO_2$		1350	2462
12	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$1{\cdot}4Al_2O_3$, $14SiO_2$		1370	2498
13	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$1{\cdot}6Al_2O_3$, $16SiO_2$		1390	2534
14	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$1{\cdot}8Al_2O_3$, $18SiO_2$		1410	2570
15	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$2{\cdot}1Al_2O_3$, $21SiO_2$		1430	2606
16	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$2{\cdot}4Al_2O_3$, $24SiO_2$		1450	2642
17	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$2{\cdot}7Al_2O_3$, $27SiO_2$		1470	2678
18	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$3{\cdot}1Al_2O_3$, $31SiO_2$		1490	2714
19	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$3{\cdot}5Al_2O_3$, $35SiO_2$		1510	2750
20	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$3{\cdot}9Al_2O_3$, $39SiO_2$		1530	2786
21	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$4{\cdot}4Al_2O_3$, $44SiO_2$		1550	2822
22	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$4{\cdot}9Al_2O_3$, $49SiO_2$		1570	2858
23	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$5{\cdot}4Al_2O_3$, $54SiO_2$		1590	2894
24	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$6{\cdot}0Al_2O_3$, $60SiO_2$		1610	2930
25	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$6{\cdot}6Al_2O_3$, $66SiO_2$		1630	2966
26	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$7{\cdot}2Al_2O_3$, $72SiO_2$		1650	3002
27	$0{\cdot}3K_2O$ $0{\cdot}7CaO$	$2{\cdot}0Al_2O_3$, $200SiO_2$		1670	3038
28		Al_2O_3, $10SiO_2$		1690	3074
29		Al_2O_3, $8SiO_2$		1710	3110
30		Al_2O_3, $6SiO_2$		1730	3146
31		Al_2O_3, $5SiO_2$		1750	3182
32		Al_2O_3, $4SiO_2$		1770	3218
33		Al_2O_3, $3SiO_2$		1790	3254
34		Al_2O_3, $2{\cdot}5SiO_2$		1810	3290
35		Al_2O_3, $2SiO_2$		1830	3326
36		Al_2O_3, $2SiO_2$		1850	3362

this condition that these stresses are probably set up most actively. The usual method of testing the tensile strength is to form the wet clay into briquettes of the same shape as those used in testing cement, and when thoroughly air-dry to pull them apart in a cement testing machine, noting the number of pounds per square inch which is required. The area of the smallest cross-section of the briquette when molded is 1 sq. in., but since the clay shrinks in drying the briquette section must be measured before testing and allowance made for this de-

crease in size. It may be said in general that the more plastic a clay the higher its tensile strength, so that some have suggested this as a means of measuring the plasticity. It is not safe to do this, however, as many exceptions occur, some very plastic clays yielding but moderate tensile strength tests. The tensile strength of different classes of clays in lb. per sq. in. may be expressed as follows: Kaolins, 5 to 25; brick clays, 60 to 150; pottery clays, 150 to 200; gumbo clays, 300 to 400.

Shales show perhaps the widest variation in tensile strength, due to the difference in degree of consolidation, for, while some are hardened by pressure alone and break down easily to the individual grains, others have more or less cementing material, and it requires a long and fine grinding to break them down to separate grains, the final result even then being the production simply of a number of compound grains which lack the plasticity and other properties of the true clay substance.

MANUFACTURE OF CLAY PRODUCTS.

Under this head will be discussed common brick, pressed brick, paving brick, terra cotta, roofing tile, floor tile and sewer pipe.

The properties of clay exert a marked influence on their use and method of treatment. Indeed, clays are at times as sensitive to change of manipulation as are ores of the different minerals which have to go through a complicated metallurgical treatment in order to facilitate the successful extraction of the metal.

The essential steps which always have to be carried out for all grades or styles of ware are: preparation of raw material, shaping or molding, drying and burning. Clay for the commonest grade of brick, or for the choicest piece of porcelain goes through these stages, but otherwise there is naturally a wide difference in the quality of the raw material, in the machines used and in the intermediate steps of manufacture.

BRICK.—Under this head are included common, pressed and paving brick.

There is probably no branch of the clay-working industry in which so little attention is paid to the raw materials as in the manufacture of common brick for building, the result being that some very inferior articles are sometimes allowed on the market. In some regions materials which might as well be called sand as clay are employed. It is, however, possible to make a good common brick from a wide range of materials, as indicated by the analyses given below, for, with the proper treatment, good bricks can be made from clays that are not only highly calcareous, but also from those that are highly siliceous. Sometimes the best results are obtained by using a mixture of materials, but unless this can be done very easily and cheaply it does not pay except for the better grades of brick. The clays commonly used for the manufacture of common brick are surface ones, of various geological ages. Thus, in the Northern States the clays are mostly of glacial origin; that is, they represent sediments deposited by streams flowing from the Quaternary glaciers, the load of rock flour that the water carried being deposited in some lake or sea; in the Western States, surface loams and clays deposited in inland seas or lakes form the common brick making

material; in the Southern States, south of the terminal moraine of the ice sheet, there is a great mantle of residual clay which is used indiscriminately for the manufacture of common building brick, it being unfortunately the sandy rather than the clayey portions that are often selected. But, in addition to this, there is also a growing tendency to utilize the materials of the coastal plain formations of the Tertiary and Cretaceous ages. Shales form another source of material for the manufacture of common brick, and in some regions, especially in southern New York, it has been demonstrated that it is perfectly possible to use this material for the manufacture of the lower grades of clay products, in those regions at least where the market price of bricks has not fallen to a minimum, as it has done in the New York market. There is probably no other place in the United States where bricks are sold at rates so reasonable.

ANALYSES OF BRICK CLAYS.

	Sandy residual clay, Roanoke Rapids, N. C.	Sedimentary clay, Fayetteville, N. C.	Loess clay, Kansas City, Mo.	Calcareous clay, Canandaigua, N. Y.	Shale, Alfred Centre, N. Y.
SiO_2	67·55	64·93	72·00	46·55	53·20
Al_2O_3	13·16	17·08	11·97	12·66	23·25
Fe_2O_3	8·54	5·57	3·51	4·92	10·90
CaO	0·17	0·43	1·80	14·02	1·01
MgO	0·28	0·59	1·12	4·67	0·62
Alk	2·65	3·85	3·25	2·05	2·70
Ign	5·08	6·58	6·42	0·90	6·30
Moist	1·63	2·48		CO_2 14·62	

The following table gives the physical properties of these clays:

	Sandy residual clay, Roanoke Rapids, N. C.	Sedimentary clay, Fayetteville, N. C.	Loess clay, Kansas City, Mo.	Calcareous clay, Canandaigua, N. Y.	Shale, Alfred Centre, N. Y.
Air shrinkage, %	8·0	8·5	5·1		4·0
Fire shrinkage, %	5·0	5·0	5·7		9·0
Tensile strength, pounds per sq. in., average	46	144	151		61
Tensile strength, pounds per sq. in., maxmium	50	175	175		62
Incipient fusion, degrees F	1900	1900	2000		1900
Vitrification, degrees F	2050	2050	2200		2050
Viscosity, degrees F	2250	2200	2300		2150

For pressed brick far greater care has to be exercised in the selection of the raw material. In the case of common brick it is simply necessary to get a clay material that will stick together in molding, and burn it to a moderately hard product, preferably of a red color; even this color is not essential, and in fact is not the rule even in some of the largest markets. A clay suitable for the manufacture of pressed brick should not only burn to a uniform color, but also yield a dense hard product at a moderately low temperature; it should not shrink excessively in burning; it should be free from soluble salts if possible, a result occasionally obtained by artificial means.

In the table of analyses on the following page, representing several types of clay used in the manufacture of pressed brick, two or three important types are included, *viz.*:

1. A red burning clay, as may be seen from its high percentage of iron oxide and its low percentage of lime or magnesia. 2. A white burning clay, with an extremely low percentage of iron—a rather rare type. 3. A semi-refractory clay low in iron oxide.

ANALYSES OF TYPE CLAYS.

Components.	1. Shale, Kansas City, Mo.	2. White clay, Grover, Cleveland Co., N. C.	3. Front brick clay, Sayre Fisher, Sayreville, N.J.
	%	%	%
SiO_2	55·75	68·28	56·10
Al_2O_3	21·16	18·83	27·42
Fe_2O_3	5·69	2·60	2·68
CaO	3·25	0·70	
MgO	2·84	0·13	0·18
Alk	3·02	2·29	2·71
H_2O	8·45	6·47	6·00
Moisture		0·76	2·90
TiO_2		0·27	1·00

Formerly the first type was used almost exclusively because the so-called red Philadelphia brick was the style, but at present the third type is mostly called for, as its low content of iron gives to the product a comparatively light color, usually buff. This shade is much in demand by architects, and the buff ground mixes well with artificial coloring agents, which enables the manufacturer to produce various shades of buff, light red, brown, gray, etc. Few pressed brick are made at present from one clay alone, the general practice being to use a mixture of several clays, in order to obtain a product of the right shade and of the proper degree of plasticity, fire shrinkage and density after burning. The behavior of the material in the latter case may often cause the manufacturer much concern, as face brick are laid up with comparatively narrow joints and it is therefore highly essential that they should fit in the proper manner.

Although the requirements of the raw material for pressed brick are very strict, still quite a wide range of materials is used in their manufacture. This is partly due to the fact that the raw substance is not the same at every locality, and partly owing to the fact that different machines work best with different grades of clay. While the analyses given above bring out a variation in the chemical composition of the material, they do not show changes in the physical character. There is not only a variation in the methods used, but also in the shape of the ware produced, so that several different types are recognized. These are:

Pressed Brick.—Includes brick with sharp and straight edges, as well as flat surfaces for facings. *Norman Tile.*—Special shape. Size, 12×4×2·5 in. *Roman Tile or Pompeiian Brick.*—Special shape. Size, 12×4×1·0625 in. *Rock Face.*—One narrow face trimmed rough after burning, to resemble stone. *Flashed Brick.*—One face deepened in color. This sometimes amounts to mere increase in the depth of color. At other times the face is fused by a reducing action of the flames, which are allowed to come into direct contact with the face of the brick.

The methods employed in the manufacture of both common and pressed brick are very much the same. They are carried out with greater care in the latter case than in the former, and in certain stages of the operation more improved forms of machinery are used for turning out the front brick.

The various methods are all summarized as follows:

1. *Preparing.*—Weathering, dry pans, rolls, barrel sieves, washers.
2. *Tempering.*—Soak pits, ring pits, pug mills, wet pans.
3. *Molding.*—Soft-mud process: (*a*) hand, (*b*) machine (hand power or horse

power); Stiff mud: (*a*) auger, (*b*) plunger; Dry clay (*a*) hand power, (*b*) steam power.

4. *Drying.*—Open yards, covered yards, pallets, tunnels heated by (*a*) steam pipes, (*b*) hot blast, (*c*) hot air.

5. *Burning Kilns.*—Up draft: (*a*) scove kilns, (*b*) clamps; continuous; down draft, (*a*) rectangular, (*b*) circular.

1. PREPARATION OF CLAY.—Under this caption are included the operations necessary to get the clay in such a condition that it can be mixed with the proper amount of water, or mixed up with other clays and molded into bricks.

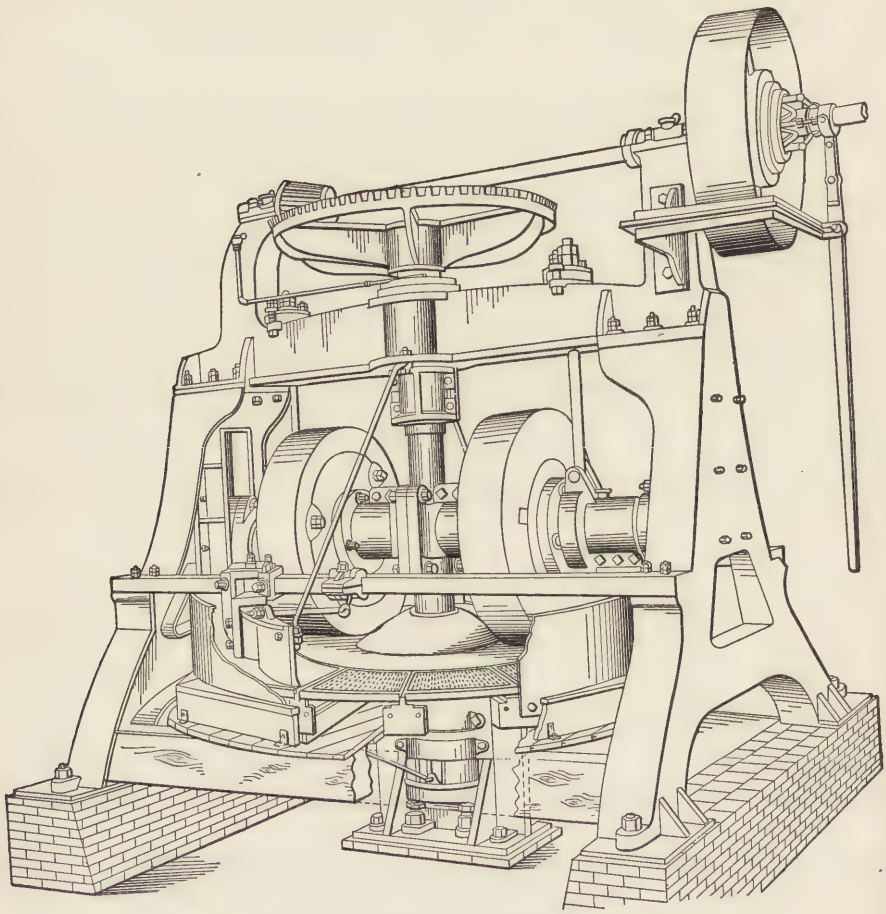
In the case of shales this may simply mean grinding it sufficiently fine; in other clays the material is first broken down to a homogeneous condition by weathering; in still others the clay, although primarily soft in its character, may contain deleterious substances which have to be washed out or screened out of it before it can be mixed with water to be formed into bricks.

Weathering—It is a well-known fact that the more homogeneous a clay the better it will mold and the more uniform and lasting the character of the product. The particles of clay, often being of infinite fineness and more or less firmly attached to each other, it is difficult to separate them all by the ordinary methods of grinding, and the material is therefore spread out on the ground in layers and left to the weather for several months (or in the case of some refractory clays, for a year or longer). As a result of this, in warm weather the moisture penetrates into the smallest pores of the material, and by freezing in cold weather it expands and aids the thorough separation of the clay particles. Further, if the clay contain organic matter, the oxidation of this and the escape of the evolved gases aid additionally in the disintegration of the mass. Other chemical changes taking place within the layer may exert similar effects. The result is that after exposure of this sort the clay is not only of more even texture throughout, but its plasticity has also been increased. There is one objection to this method; *viz.,* that any sulphides contained in the clay may be changed to sulphates and thereby pass into a soluble form. This is sometimes detected by the formation of a white salt on the clay, and is very apt to occur in those clays containing pyrite.

Dry Pans.—These are chiefly used for breaking up shales or very tough clays. They consists essentially of a circular pan from 7 to 9 ft. diameter in which there are two iron wheels on a horizontal axis. They are made to revolve by friction against the bottom of the pan, the latter being turned by steam power. (See Fig. 2.) In a 9-ft. pan the rolls are 48 in. in diameter and have a 12-in. face. The combined weight of the two rollers, with shaft boxes, is 13,000 lb. The bottom of the pan consists of a series of cast-iron plates perforated by a number of rectangular slits whose width varies commonly from one-sixteenth to one-quarter of an inch. They are removable, to permit replacement by others in case of breakage, or in case the fineness of the grinding is to be changed. The two wheels weigh from 2,000 to 5,000 lb. each, and the axle on which they revolve has spring bearings which permit a certain amount of vertical play to them in case very large pieces get into the pan and come under the rolls. As soon as the material is ground sufficiently fine it passes through the perforated plates

and is carried off either on a traveling belt or in a bucket elevator. Two scrapers are set in front of the rollers to throw the unground material in their path as the pan revolves. The capacity of a dry pan will naturally vary with the character of the material and the degree of fineness to which it is to be ground. With average material it can be said, however, that a good dry pan will grind about 100 tons in 10 hours through 8-mesh screens.

Roll Crushers.—These are sometimes used for crushing clay, but are not



(Manufactured by Chambers Brothers Co., Philadelphia, Pa.)

FIG. 2.—DRY PAN FOR CRUSHING SHALES OR VERY TOUGH CLAYS.

usually as satisfactory as pan crushers, nor do they perform the crushing as thoroughly. They are also used at times for breaking up soft clay, and in this respect are still less satisfactory.

Barrel Sieves.—Many clays contain lime in the form of limestone pebbles, which is perhaps its most injurious mode of occurrence, because in burning the lime carbonate becomes converted into quicklime, which tends to absorb moisture later and sometimes swell to such an extent as to burst the brick or other

piece of clay ware containing it. If therefore the clay is soft and fairly dry when dug it takes little extra time and labor to dry it sufficiently for screening, after perhaps a slight preliminary disintegration. The screening serves to free the clay from the lime pebbles and avoids a possible cracking of the finished product.

Washers.—These represent a second class of machine used to remove lime or other pebbles from clay. Washing the clay for this purpose is often practiced in Europe, but is seldom carried out in the United States except in the case of high-grade clays. The process is similar to that of blunging carried out by potters in the mixing of their porcelain or earthenware bodies, but is less thorough and is carried out with cruder machinery.

The machines used differ somewhat, but generally consist of a circular pit or tank, which may vary in diameter from 6 to 25 ft., according to the capacity of

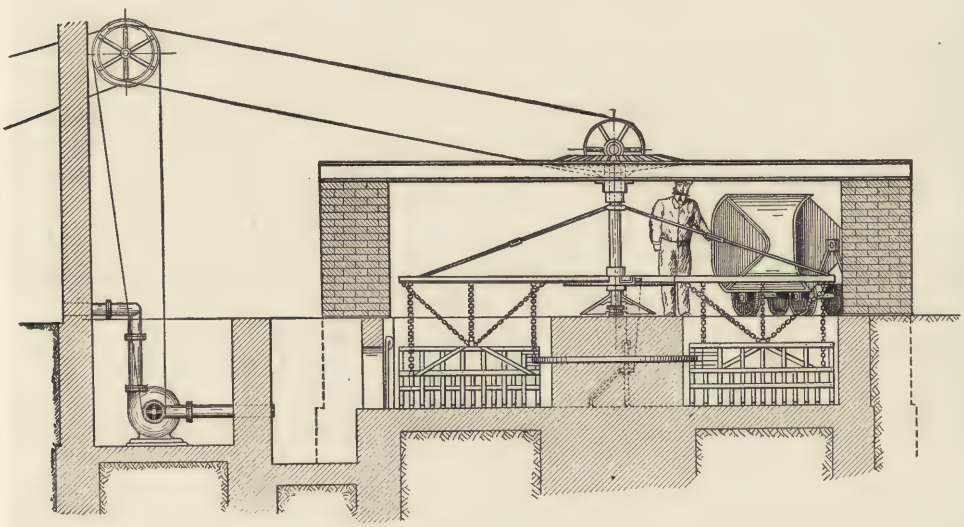


FIG. 3.—SECTIONAL VIEW OF WASHING TANK, SHOWING THE CENTRIFUGAL PUMP FOR RAISING THE SLIMES INTO THE SETTLING TANKS.

the machine. In this pit is a vertical shaft which revolves at a slow rate of speed. If the pit is small the shaft bears a series of horizontal arms or stirrers, but is of greater diameter; the general method is to have two horizontal arms attached to the shaft at a height slightly below the top of the pit. Hanging from these arms are a series of fixed or hinged rake teeth, which in some cases touch the bottom of the pit. The operation of mixing is done as follows: Water is run into the pit and the arms revolved, the clay being shoveled in at the same time. The slacking action of the water breaks up the clay and the motion of the arms keeps the finer particles in suspension while the pebbles and sandy particles fall to the bottom. As a stream of water runs into the pit continually and flows off through a trough, the clay particles are carried off, while the coarser sediment remains. Unless there is some special device for the removal of the sand the machine has to be stopped from time to time to clean

out the bottom of the tank or pit. Fig. 3 represents a common type of European washer. The water with the suspended clay is allowed to run off and settle in pits dug in an adjoining field or in shallow excavations that are lined with planking.

In the washing process the nature of the clays exerts considerable influence. Sandy clays, being less coherent and more open-grained, fall to pieces in the water more readily than clays of a more plastic character.

A washing method of this kind is especially applicable in regions around the Great Lakes, where many of the surface clay deposits contain large quantities of lime pebbles, and at a few places in this area the washing method has been tried with success in the manufacture of common brick. At one yard where this is done the tank is 6 ft. in diameter and 5 ft. high. Two men in one day of 12 hours can put through this washer sufficient clay for 16,000 brick.

2. TEMPERING.—This operation consists in mixing the raw materials with water to a pasty mass of the proper consistency for molding. The attainment of this object is not always possible by the use of one clay alone, and it is therefore found necessary at times to admix two or three clays. This is not only for the purpose of obtaining a mixture of the right plasticity, but also to get the desired qualities for the later stages of the manufacturing process. Some clays are too plastic, while others are too lean; that is, they lack plasticity. Some are too fusible, and have to be mixed with others which are more refractory. Similarly we have to combine clays of low shrinkage and high shrinkage. The object in every case is to arrive at a happy medium, and for a proper mixture of these different elements tempering machines are required.

In common-brick manufacture, where a single clay of proper quality is not found, the method mostly used is to intermix a certain amount of sand, known as tempering sand, in order to lessen the plasticity of the raw material and to prevent excessive shrinkage in burning. There are four chief types of machines used for tempering.

Soak Pits.—These represent the simplest form of contrivance for the mixing of brick clays, although fire brick manufacturers also use them as a preliminary step in the thorough tempering of their raw materials. They consist of a rectangular pit, usually about 3 to 4 ft. deep, and about 6×8 ft. or more in area. Generally the lining is wood but may be of brick. The clay or clays are dumped into this pit as soon as they are brought from the bank, water poured on the mass and the whole allowed to soak over night for use on the following morning. It will thus be seen that the chief object of a pit is to permit the addition of sufficient water to the mass and to give it time to soak in evenly and thoroughly. The degree of soaking depends on the porosity or sandiness of the clay. Very dense ones will resist the rapid percolation of the water. A breaking up of lumps may also occur in the pit as a result of simple water slaking of the clay. In most yards where common brick are manufactured it is customary to add a certain amount of sand to the clay, and at times some coal dust as well. These are spread in alternate layers, and, while the water does not actually effect an admixture of them during the soaking process, still, as the material is shov-

eled out of the pit into the machine, the workman in digging downward into the mass gets an average section of the material with every shovelful.

Ring Pits.—These are a step in advance of soak pits, and are employed at many common-brick yards, as they do the tempering work in a far more thorough manner. They consist of a circular pit from 15 to 20 ft. diameter and from 2 to 2·5 ft. deep, in which revolves an iron wheel on a horizontal axis. This wheel is so geared that as it travels around the pit it also moves from the center to the circumference and back again. The clay is charged into the pit, which is generally lined with planks. Water is poured on the mass and the wheel started. The tempering process takes about six hours. One large pit will temper enough material for a day's output of two soft-mud machines, each having a capacity of about 20,000 brick.

Both of the foregoing methods, as already stated, are confined mostly to common-brick making and are seldom seen in use at a pressed-brick plant. The reasons for this are several. In the first place neither of the machines temper the clay with sufficient thoroughness. Secondly, they do not temper the material quickly enough to supply a machine of large capacity. On this account a machine known as the pug mill is often used.

Pug Mills.—These machines if properly constructed are thorough in their action and possess a large capacity as compared with the machines above described. In its general form the pug mill consists of a cylindrical box or semi-cylindrical trough, usually in a horizontal position, closed at one end, while at the other it tapers off to a circular opening. In this trough or box revolves a horizontal axis, bearing knife blades, set at an angle, so that their action on a mass of clay is somewhat similar to the thread of a screw conveyor. In working, the clay is charged at the end of the pug mill farthest from the opening and a stream of water directed upon it. The effect of the revolving arms and knife blades is not only to cut the clay up and mix it with the water into a homogeneous mass, but also to move it forward toward the discharge orifice at the same time. It will be seen that if the pug mill is too short the clay will not receive sufficient mixing, and in the case of two clays being mixed together the pug mill used should not be less than 6 ft. in length.

Wet Pans.—These represent probably the most rapid and efficient means of tempering at the present time. They are very similar in construction to dry pans, but differ from them in having a solid instead of a perforated bottom to the pan. The material is charged in small quantities at a time together with the necessary amount of water, and the action of the wheels not only grinds up the clay, but mixes it thoroughly as well. As this only requires a few minutes, the charge can be removed immediately and another one added in its place.

3. Molding.—Bricks are molded by one of five methods: (1) Hand molding, (2) soft-mud machines, (3) stiff-mud machines, (4) dry press, (5) semi-dry press.

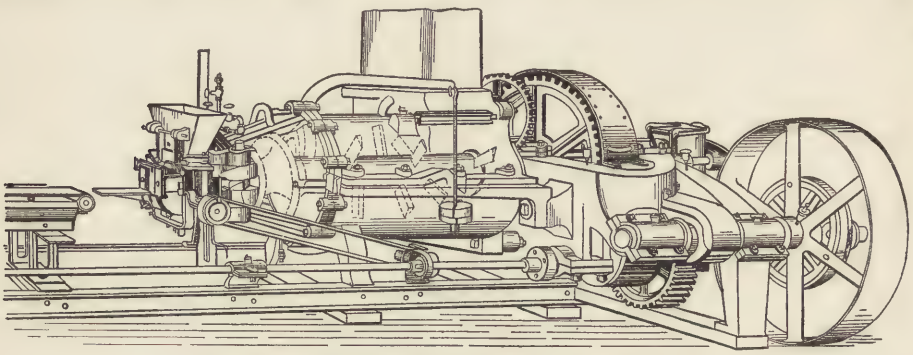
Hand Molding.—This operation consists in simply forcing the wet clay by hand into wooden molds, and is used at small yards where the demand is very limited. In the Northeastern States very few hand-mold yards are seen.

Soft-Mud Machinery.—This method is a step in advance of hand molding, and

consists in performing the same thing by machine. Most soft-mud machines operate on the same general plan, and consist essentially of an upright box which is practically a vertical pug mill. The clay passes downward through the machine and is forced into a six-compartment mold at the bottom, which has been previously sanded. When filled with clay the mold is thrust forward automatically, removed by hand and carried to the drying floor.

Machines of this type require from five to seven men to operate and will turn out about 20,000 brick per day. Soft-mud machines are very largely used in the manufacture of common brick, although they have been superseded to some extent by stiff-mud machines, which have a greater capacity. The advantages of soft-mud machines are: that they are applicable to a wide range of clays; they produce a brick of uniform texture, which if properly burned has excellent weathering qualities; and it is probably the cheapest method of molding. The disadvantages are: limited capacity and imperfect smoothness of product.

Stiff-Mud Process.—The nature of this operation is partly denoted by its name, for by the use of less water the clay is mixed up to a much stiffer paste



(Manufactured by Chambers Brothers Co., Philadelphia, Pa.)

FIG. 4.—A STIFF-MUD BRICK MACHINE OF THE AUGER TYPE.

than in the soft-mud machines. The mixing is commonly done in a pug mill, from which the clay is discharged into the machine. The stiff-mud machine of the auger type as mostly used at the present time (Fig. 4), consists of a cylinder, closed at one end, the other being converged toward an opening onto which is fitted a rectangular steel die. The section of the die is of the same area as either the end or top of the brick. In the cylinder revolves a horizontal axis, bearing knife blades, and at the end of the axis near the die is a screw. As the clay is discharged into the machine from the pug mill, it is seized by the blades on the revolving axis and passed along until it is within reach of the screw which forces the clay out through the die in the form of a rectangular bar. This clay bar is received on a cutting table and cut up into bricks in one of two ways: (1) The bar issues a certain distance, stops and is cut through by means of a series of parallel wires carried on a frame which slides across the delivery table or belt. (2) The action is continuous and automatic, and is accomplished by a wheel which has a series of wires that cut the bar. The bricks as soon as cut are either removed by hand or else received on a

second belt which is traveling at a greater rate of speed than the first, thus separating them from each other. They are then removed by hand. The plunger type of machine, now nearly out of use, differs from the auger type in having a vertically placed pug mill.

The stiff-mud machine is far more complicated than the soft-mud one, and while greater results are possible it is more sensitive to various influences. In the first place the flow of clay through a die is not smooth, for the clay acts like a stream of tar or water and the friction of the clay against the sides of the die will cause the central portion of the bar to flow faster than the outer part, which will tend to produce shearing surfaces. Again the action of the screw will twist the mass, and induce a spiral structure in it. This is found actually to be the case and in many bricks made by the stiff-mud process, there is a distinctly shelly structure visible on the fracture. This defect can be overcome to a certain extent by preventing as much as possible the friction against the sides of the die with steam or oil lubrication. The proper internal structure of the die itself also makes a vast difference in the structure of the product, and numerous patented forms have been designed to overcome the defect noted above. Moreover, it has been found that the greatest spiral lamination is produced by the use of very plastic clays, hence these should be avoided and moderately plastic ones chosen. Care must be taken, however, to avoid the other extreme, the use of clays of too great leanness, else the bar will tear and crack as it issues from the die. The imperfect adjustment of clay to die is sometimes seen in the formation of a serration on the edges of the bar as it emerges, a result also obtained at times by the use of too little water in tempering.

Consequently it is a difficult matter to state the exact requirements of a clay for the stiff-mud process. Medium plasticity is the most important factor perhaps, and with this should go a good tensile strength. It is next to impossible to state whether a clay can be molded by this method until it has been in actual trial, on more than one machine, for clays that could not be utilized with one form of stiff-mud machine, have given an excellent product on another machine of the same type, which did not seem to possess any essential difference. There are unfortunately many small and cheap stiff-mud machines on the market, which are sold for use without a pug mill, and are so short that the clay does not get sufficiently tempered in passing through them. In many cases these machines yield poor results, which are intensified by the fact that the manufacturer seeks to increase the capacity of his yard by fitting his machine with a triple die. There are works, however, which use double dies and in some cases triple ones with success. With a triple die the clay issues in the form of three parallel bars.

There has recently been introduced in the German market a most curious form of triple-die machine, or rather one having three separate dies. One is situated on the end of the machine while the others are on the right and left side of the machine respectively, so that the second and third bars of clay issue in opposite directions but in a plane at right angles to the first. So far as the writer is aware this machine has not been widely used. The special advantage claimed is that three different shapes can be molded at the same time.

The advantages of the stiff-mud method are: great capacity, a single die

machine being capable of turning out 40,000 brick in 10 hours; comparative cheapness; and a product which is smooth on four of its faces. The disadvantages are: spiral structure often developed in the brick; restriction in the number of varieties of clay that can be used. If properly burned the effect of any irregularities of structure is often counteracted, and often may be further eliminated by proper re-pressing.

Dry-Press Process.—This as the name also implies consists in pressing the clay in the dry condition, or at least with a very small amount of moisture in it. The clay is commonly dried, ground and screened and then discharged into the hopper of the dry-press machine. From this hopper it is forced automatically into steam heated steel molds which have a movable bottom. As the mold is filled, the plunger which is over it descends and by means of a toggle joint arrangement brings great pressure to bear on the pulverized clay in the mold. As the plunger rises, the bottom of the mold follows it thus raising the brick up to the level of the delivery table upon which it is automatically pushed forward. Four or six brick are usually molded at a time.

The semi-dry clay process uses the same machinery as the dry-press process, but moistens the clay very slightly. The dry-press method differs materially from either of the two preceding ones. Since the clay is used in a nearly dry condition the property of plasticity does not come into play; the only requirement is that the clay should stick together by cohesion sufficiently long to permit of its being placed in the kiln and burnt, and to support the weight of the green bricks that are placed on top of it, until fusion cements the body together. This degree of cohesion in the clay will be influenced by the percentage of sandy and clay particles that are contained in the raw material. This process permits the use of a wide range of clays, from those containing a considerable percentage of sand, to others having a large amount of clay substance. The relative proportions of these two do not have to be considered here in their relation to the air shrinkage of the clay, for as no water has been added in tempering or preparation there is none to evaporate, with the exception of the slight amount of moisture which surrounds the clay grains as a thin film. In burning, the relative abundance of the plastic and non-plastic constituents will exert itself, and cause a variation in the fire shrinkage of different clays; the greater the quantity of clay substance that the clay contains, the larger the amount of combined water that must be driven off and consequently the larger the fire shrinkage. One element that has to be considered in the dry-clay process is the presence of air between the clay particles. This air so imprisoned is subjected to compression during the process of molding and when the pressure is relieved it tends to expand, with the result that unless provision has been made for its escape, the brick may crack by this expansion. Generally this effect is avoided by having openings in the mold through which the air can escape.

In addition to the wide range of clays that can be used, other advantages possessed by the dry-process method are: the uniform texture, smooth surface and sharp edges of the product made at one operation. Unless the brick is burned hard it is often very porous and breaks rather easily on the edges. This necessitates careful handling both in shipment and laying. Partly on this account and

partly owing to the fact that a surface of dry-pressed brick is often too shining and smooth in appearance when set in the wall, many architects prefer a repressed soft-mud or stiff-mud brick for exterior use. The cost of manufacture of dry-press brick is comparatively small but the initial cost of plant is large.

4. Drying Bricks.—The relation that exists between the method of drying and the properties of the clay is fully as intimate as in the case of molding. In the drying, it is not only necessary to expel the mechanically combined water that the clay contains, but also to see that the shrinkage which occurs as a result of the evaporation is done without injury to the brick in any way. For the sake of economy, it is naturally desirable to get rid of this moisture as rapidly as possible and a clay should be used whenever practicable which will permit this. As a matter of fact clays which are so open in their texture that they will give off their moisture very quickly without injury to the brick are very likely to be so lean as to be undesirable for brick materials. Furthermore, the item of transportation and market price often necessitates the use of the nearest deposit of clay, treating it as can best be done under the circumstances. The drying operations must therefore be governed largely by the character of the raw material. Highly plastic clays which have a large amount of moisture, as well as fine-grained sandy ones, have to be dried slowly to prevent cracking. Coarse-grained ones on the other hand will often permit rapid drying. If the clay contains soluble salts these are almost invariably brought to the surface by the evaporating moisture.

Bricks are usually dried by one of the following methods: Open yards, covered yards, pallet yards, tunnel dryers and drying floors.

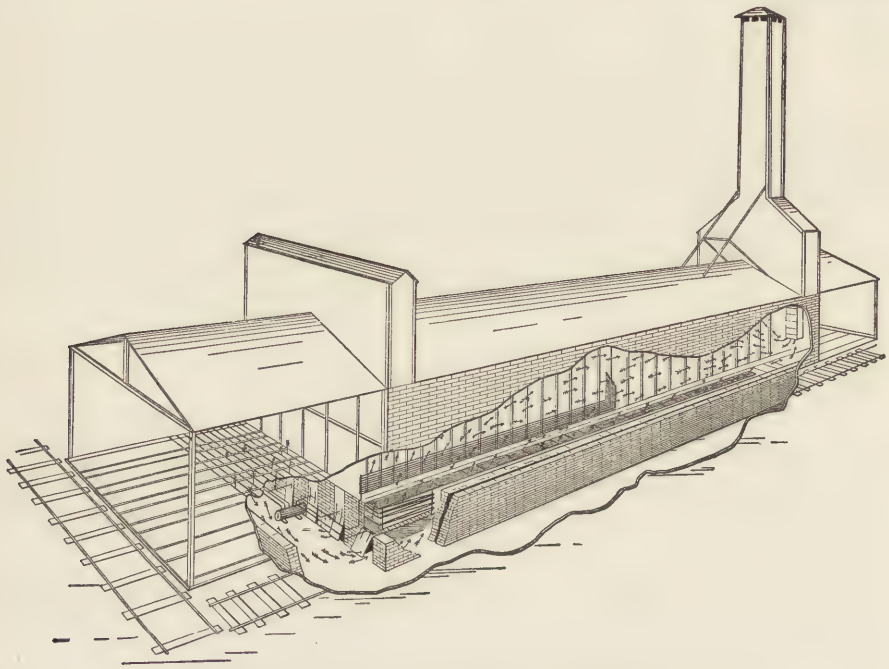
Open Yards.—These are often used at common-brick works, especially in connection with soft-mud machines, as their use involves but slight cost. They consist of a brick or hard earth surface on which the bricks are spread out in the sun to dry, each yard, as a section is called, being sufficiently large to hold the daily output of one machine. At the end of the day or sooner the bricks are usually turned on edge and on the following day they are often sufficiently dry to handle, when they can be stacked in piles five or six courses high and left until ready to be placed in the kiln.

Covered Yards.—These differ from the preceding in having a roof which is often of movable sections. In pleasant weather they can be lifted which permits the sunlight to fall on the bricks. Their only advantage over open yards is, that no rain-washed bricks are produced.

Pallet Yards.—These consist of a series of racks with horizontal cleats to receive the boards or pallets on which the bricks are carried from the molding machine. The pallets are set one above the other so that there is a clear space of 3 or 4 in. above each pallet full of bricks. The advantages of the pallet rack system are that it increases the drying capacity of the yard and the bricks are not liable to injury by rainfall. On the other hand they do not dry so quickly as in open yards and the cost of construction is slightly greater. Nevertheless manufacturers of common brick are adopting them in nearly every instance.

Tunnel Dryers.—This method of drying brick is probably employed at every pressed brick plant and even at some yards manufacturing common brick only,

for the reason that it eliminates several uncertain elements. The system is practically independent of the weather and yields a greater capacity. A tunnel dryer consists of a series of tunnels side by side, having a track laid in each. The tunnels are closed at the ends by means of counterbalanced doors which are easily lifted to permit the passage in or out of the brick. As the bricks are taken from the molding machine they are loaded on cars which are run into the cooler end of the tunnel being gradually pushed through by the introduction of other cars after them. They come out at the other end of the tunnel after a period of from 18 to 36 hours. The green bricks, if sufficiently stiff to bear the weight, are piled on top of one another, each car holding about 300 or sometimes 400 brick. At other times the car is provided with an upper deck. When used



(Constructed by the Standard Dry Kiln Co., Indianapolis, Ind.)

FIG. 5.—THE STANDARD DRYER, USING STEAM PIPES.

with soft-mud machines, pallets with feet are usually employed, so that these may be set one on top of the other without the brick touching. The essential point of difference between the drying systems of the type lies in the methods of heating the tunnels, which are as follows:

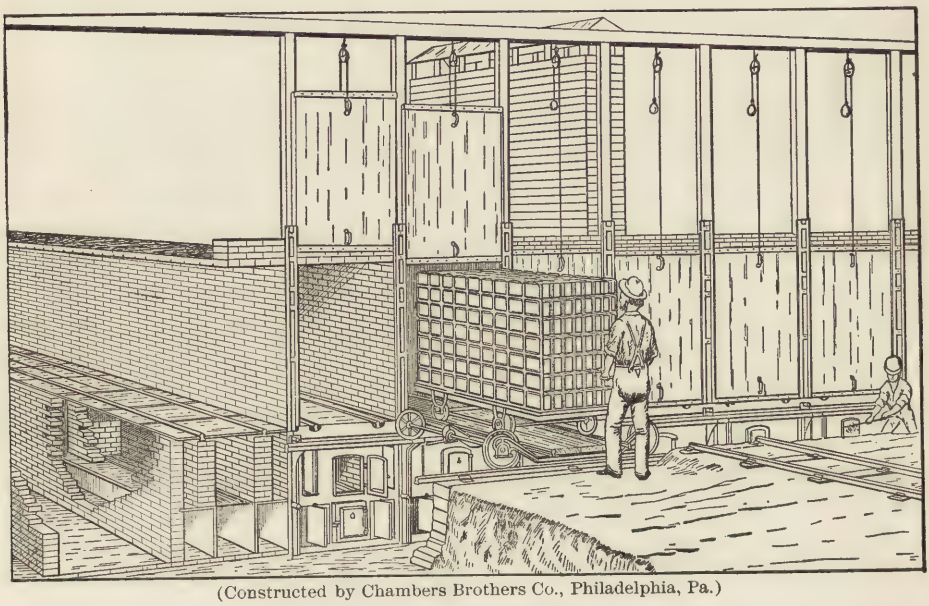
1. *By Hot Air,* derived from the waste heat of the cooling kilns and forced through the tunnels by means of a fan.

2. *By Steam Pipes.*—(Fig. 5.)—As in the Standard dryer. These are laid either along the bottom of the tunnel between the tracks or are fastened on the inner walls.

3. *By Flues.*—(Fig. 6.)—Running under the tunnels, and heated by fires located under the end at which the dried bricks are taken out.

There has been much discussion over the relative merits of the different systems and it is not safe to declare definitely in favor of any individual one, although certain systems are undoubtedly more economical than others. Thus for instance the flue system entails the constant use of coal to keep the tunnels heated while, on the other hand, the two other methods can be made to utilize waste heat, in one, obtained from the cooling kilns, and in the other from waste steam. When waste heat from the kilns is utilized means must be provided to permit its dilution with cold air before it enters the tunnel.

The end of the tunnel at which the bricks enter is of course the cooler. Great care is necessary to have sufficient current velocity within the tunnels in order to remove the evaporated moisture and to keep the temperature regular. To insure this the dryers are commonly supplied with stacks at the hotter end and in some



(Constructed by Chambers Brothers Co., Philadelphia, Pa.)

FIG. 6.—THE TUNNEL DRYER.

cases small fans are placed in the end of the tunnel to help the draft. Furthermore, the lower portion of the tunnel should be as hot as the upper part, so that all bricks on the same truck will dry with equal rapidity; this condition, however, is unfortunately not always fulfilled. The time that it takes for a car to go through the tunnel about 100 ft. long depends on the clay. Some clays will go through in 18 hours, while others require 48 hours. The thinness of the ware must also be considered, the thinner products drying more rapidly than the thicker ones. Even with the same clay there will be some variation in the period of drying, depending on the weather and the effect which it exerts on the draft in the dryer and upon the freedom of the entering air from moisture.

5. BURNING.—This is a most important step in the process of brickmaking, and calls for considerable skill. It involves many chemical reactions and physical changes whose proper control is essential to the good quality of the product.

The physical changes that take place during burning are shrinkage, fusion, change in color and hardening. Fire shrinkage is greatest in highly plastic clays and highly aluminous ones and least in sandy ones. Greater in the two former mentioned because plastic clays have absorbed much water which must be rejected and because the presence of high alumina percentage indicates much clay base which has to part with its 13% of combined water. Other hydrates if present also contribute to the fire shrinkage, for the same reason. Furthermore the presence of much organic matter in a clay might add to its fire shrinkage, for this material passes off when the temperature of redness is reached providing the clay has been heated slowly. We can therefore to some extent counteract the fire shrinkage by avoiding clays or a clay mixture with a high percentage of alumina, of highly plastic qualities, or with much organic matter.

Change in color is due almost invariably to the presence of iron oxide in the clay. If in burning, a sufficient quantity of air enters the kiln to keep the interior in an oxidizing atmosphere the brick will be red, since the iron compounds are kept in the ferric condition. If the reverse is true, the iron compounds are reduced to the ferrous state and the product will be blue or bluish black. This is the effect produced in the manufacture of flashed brick. It is also the cause of the peculiar color in the Staffordshire blue brick. In the latter case the reducing action is only brought about during the later portion of the burning, so that the brick or block has a shell of reduced iron compounds surrounding the interior portion which is still red, since the reduction effect has not had time to penetrate to the center. It should be remembered, however, that the iron oxide contained in clays oxidizes very readily and even though a blue color may have been produced artificially still if in cooling, the kiln is not kept well sealed against the entrance of air, the iron will once more revert to its ferric condition.

Fusion and hardening should really be described together, as the one is the result of the other. Unless fusion has at least begun, the product will not be hard and rock-like, for it is the softening of the particles under the action of heat that binds the whole together into a firm hard mass, which often can be scarcely scratched by a knife. Fusion begins at different temperatures in different clays and in every case it begins gradually as already explained under the caption, "Fusibility." In many brick clays, incipient fusion occurs as low as 170 or 1,800° F. while vitrifiication is not uncommonly attained at 1,900° F. The completion of incipient fusion and the attainment of the point of virtrification means a slight additional shrinkage because when this stage is reached many of the clay particles and even some of the sand grains are so soft that they can adjust themselves to each other and thereby close up all the pores, forming a compact impervious mass.

The chemical changes that occur during the burning are in part closely related to the physical ones, and in part independent of them. Among these changes may be mentioned: the driving off of chemically combined water; the expulsion of carbonic acid gas from the carbonates; the oxidation to sulphates of sulphide minerals, such as pyrite. (The latter, however, is subsequently changed to oxide.) If the heat is sufficiently high the sulphates are decomposed

and sulphuric acid gas is given off. When fusion begins the chemical reaction between the various ingredients of the clay commences also, and results in the formation of complex compounds which usually have a lower fusion point than any of their components. One of the most important points in the burning of clay wares is to proceed slowly during those stages of the burning when chemical or physical changes are taking place.

Probably the first change that takes place in the kiln is the expulsion of the last traces of moisture that the clay contains. During this stage, which is known as water smoking, much steam is given off and some shrinkage occurs. Water smoking has to be carried on slowly to avoid unpleasant results. If any soluble salts remain in the interior of the ware they are very apt to come to the surface

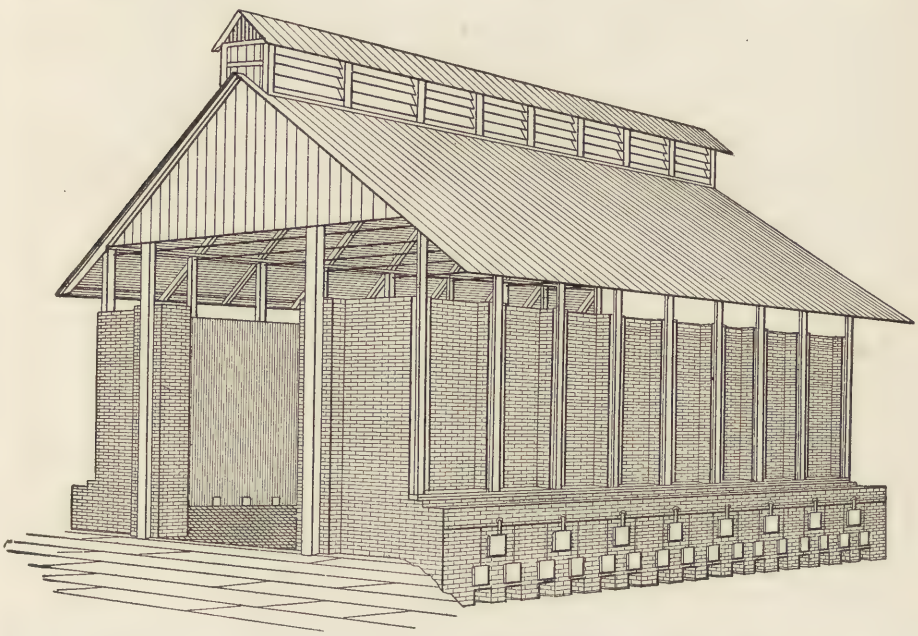


FIG. 7.—THE GRATH RECTANGULAR UP-DRAFT KILN WITH PERMANENT WALLS AND GAS AND COKING FURNACES.

and form a white coating unless the temperature becomes sufficient to decompose them. The next change, which probably begins before redness is reached and is finished at bright red heat, is the oxidation of the iron and the driving off of organic matter. Following this comes fusion and the expulsion of the combined water, although fusion may not begin until after the combined water has been expelled, especially in the case of very refractory clays.

Kilns.—Various types of kilns are in use. The old method of burning brick in scove kilns which was practiced for so many years, especially at common-brick yards, is rapidly passing out of use and the modern up-draft rectangular kiln together with the continuous kiln is taking its place even at yards which produce common brick alone. Manufacturers are finding that the advantages of these more modern forms are worthy of serious consideration. The use of a

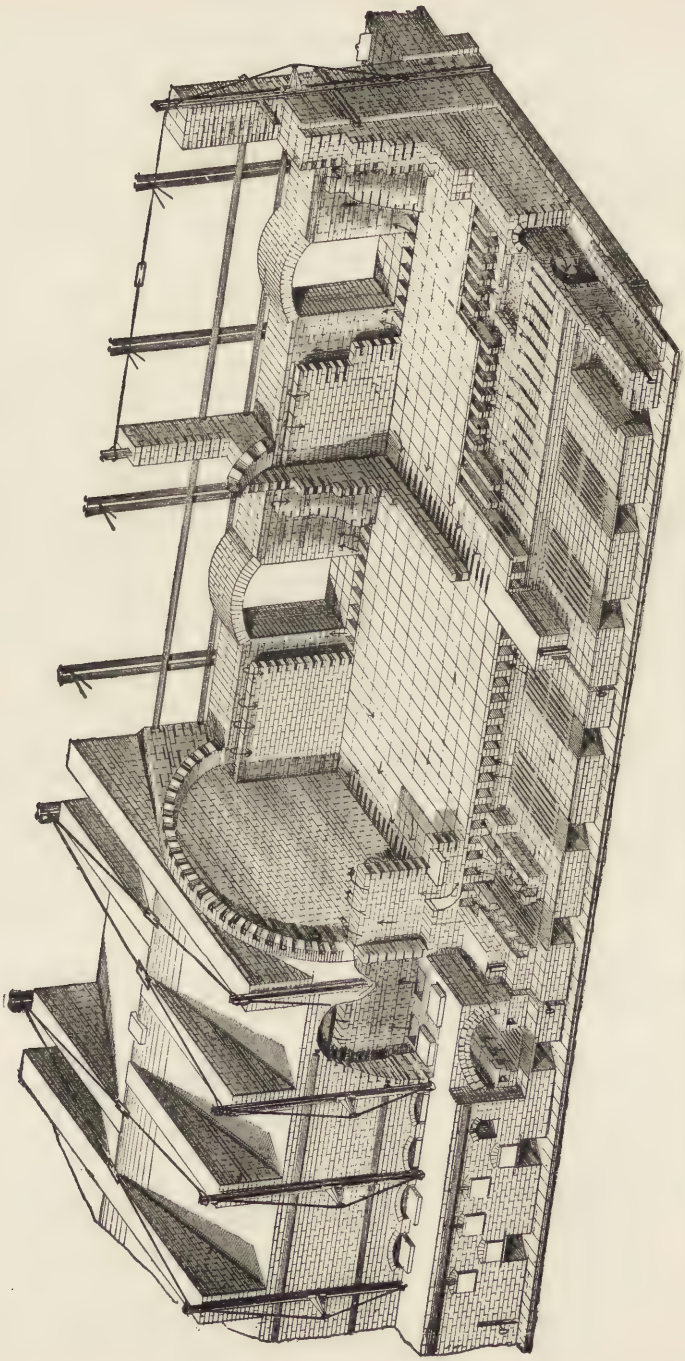


FIG. 8.—THE GRATH RECTANGULAR CONTINUOUS DOWN-DRAFT KILN WITH RADIATING FLOOR.

better type of kiln means a saving in labor, fuel and half burned brick as well as a better color of the product. All these factors not only lessen the cost of production but also increase the market value of the product, and by the use of these modern kilns the cost of brick burning has been materially reduced, amounting in the case of continuous kilns to a reduction from 60 or 70c. to 25c. per thousand.

Scove Kiln.—This kiln is temporary in character. In burning the bricks are piled up 35 to 40 courses high and divided into sections of about 35,000. At the bottom of each section an arch-like space is left running through the mass and when the entire lot of brick to be burned has been piled up it is surrounded by a wall of brick with the exterior plastered with mud. A fire of wood or coal is built at the ends of each archway and fuel added from time to time until the whole mass becomes heated to a bright red. The proper circulation of the heat and air through the mass is controlled in an imperfect way by doors over the arches and by a layer of brick set flat on the top of the kiln known as the "platting." The farther corners of the kiln receive an insufficient quantity of heat which is counteracted by adding coal dust to the clay.

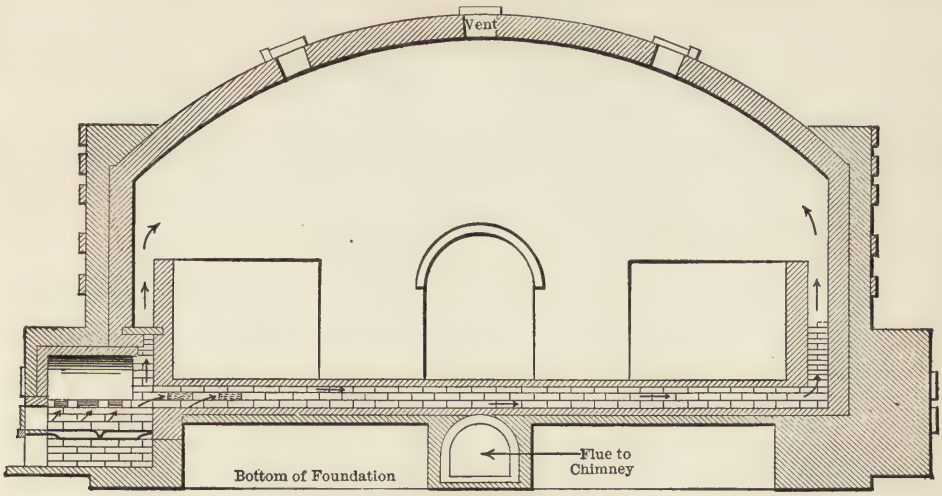
A step in advance of this type was one with two permanent side walls (Fig. 7), containing the fire-places but lacking a roof and ends. The former had to be supplied by the platting and the latter by bricking up after the bricks had been set in the walls. Even this is far from satisfactory and from it there has developed the modern kiln enclosed on all four sides and covered with an arched roof. The fire-places are set into the two long sides when the kiln is rectangular, their number depending on the size of the kiln. The brick are put into the kiln through the two doorways in the ends which are subsequently bricked up. A kiln of this character has a capacity of from 60,000 to 150,000 or even 200,000 brick. The first ones were of the up-draft type. That is the fire entered the kiln at the bottom direct from the fire-places, passed upward through the mass of bricks and out through the flues or chimneys in the top of the kiln. The result of this system of firing was that the bricks in the lower portion of the kiln received more heat than those at the top, and in order to heat the latter sufficiently the lower ones were apt to become softened to such an extent that they were crushed out of shape by those above them.

Down-Draft Kiln.—(Fig. 8.)—This type of kiln was introduced to remedy the defects of the up-draft kiln. These were of the same shape but differed in having on the inside wall a pocket or flue that led from the opening of each fire-place, upward along the inner wall of the kiln. There were also a series of openings in the floor of the kiln which connected with flues that passed to the chimneys or to a common stack. The improvement through this method is at once apparent. The burning gases from the fire-places pass first to the top of the kiln, then downward through the mass of brick and out through the openings in the floor. This reverses the conditions of the up-draft kiln and the bricks on top receive the greatest amount of heat. If therefore they became slightly overheated in an attempt to burn the bricks in the bottom thoroughly there was no danger of their becoming crushed out of shape. The modern down-draft kiln possesses many advantages: It avoids misshapen brick if the burning is properly con-

ducted; there is a more even distribution of temperature throughout the kiln; the fires can be better controlled than in the old scove kiln and a more uniformly colored product is often obtainable. Kilns of this type are constructed in circular form as illustrated in Fig. 9.

In both the up-draft and the down-draft kilns, several kinds of fuel have been used in different ways. In the old up-draft kiln, wood was at first the only fuel employed but owing to its low calorific power and to its reducing action at times, it was abandoned at many works in favor of coal or oil. Of these three fuels oil is the cheapest under many conditions as well as the cleanest, but on the whole, coal has found greater favor, ranging intermediate in price between wood and oil. The oil is fed into the kiln through a burner situated in each firing place. When coal is employed several different methods of charging have been tried. The first consisted simply in placing it on the grate bars and allowing the ashes to fall through into the pit or space underneath. In a few works grate bars have been discarded and the coal charged on the brick floor of the hearth. Another type known as the Grath coking furnace has a coking table about 16 in. above the combustion chamber. The fuel is first charged on this, and part of the heat of the combustion chamber is drawn under the coking table which keeps the coal on the table red hot and drives the gases from it. These gases are ignited and burned in the passage through the flues into the kiln. As soon as the gases are expelled from the fuel the residue is shoved into the combustion chamber and is there consumed while fresh fuel is added to the coking table. The use of this system it is claimed obviates the passage of unconsumed carbon into the kiln.

Continuous Kilns.—The down-draft and up-draft kilns as normally designed, do not utilize the waste heat and with this end in view the continuous kiln was devised. The original type was invented by F. Hoffman and, while at the present time there are numerous others in use many of which are patented, for the most part they are modifications of the Hoffman principle. The principle of these kilns is probably so well known that a brief description will suffice. They consist of a series of chambers set either in a straight line, or in the form of a circle or oval. Each chamber has a capacity of about 22,000 brick and is connected by flues with a central stack and also with the two adjoining chambers, on either side. Some types have in addition a small fire-place for each chamber while others have a temporary one in the brick work that is used to seal up the doors of the chamber after it has been filled. The principle of the kiln is as follows: when ready to start all the chambers having been filled a fire is started in one and the vapors that pass off during the process of water smoking are led to the stack. As soon as this is completed, the heat and gases passing off from the burning chamber instead of being allowed to escape to the stack are led through two or three of the following chambers which are yet to be burned. In this way the waste heat of any one chamber is utilized to heat up several of the succeeding ones. In the continuous kiln proper, there are several small openings in the roof of each chamber and in setting the bricks an open space is left which extends downward through them under each one of these openings. As soon as the chamber is heated to dull redness or perhaps more by means of the waste



Section through Fire-place.

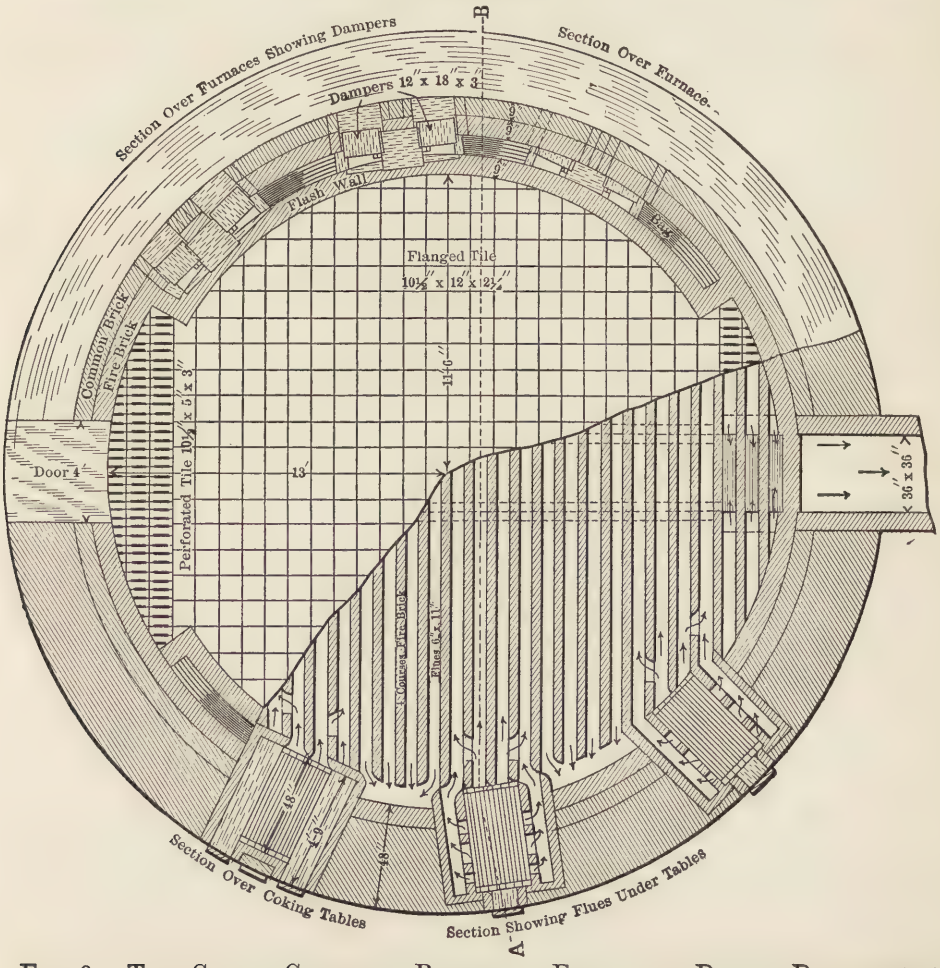


FIG. 9.—THE GRATH COMBINED RADIATING FLOOR AND DIRECT DOWN-DRAFT KILN WITH ATTACHED GAS AND COKING FURNACES.

heat the caps are removed from these openings in the roof and small quantities of coal dust or other fuel are charged in them from time to time until the burning of the chamber is completed. During the operation of the continuous kiln therefore, the burning, filling and emptying of chambers is going on at the same time, for the bricks can be removed from any division of the kiln as soon as they are cool and in filling the chambers it is only necessary to keep far enough ahead of the one at maximum temperature to utilize all waste heat. For example, there will thus be one chamber at a maximum heat while in front of it will be others whose temperature is rising and behind it those which are cooling. In some continuous kilns there is a solid brick wall between the different chambers but in most types in the United States there is none, the kiln resembling a continuous tunnel. When the bricks are set in the chambers a temporary partition is formed by covering the surface of the bricks with a layer of heavy brown paper, which lasts sufficiently long to prevent the free circulation of the air through the kiln and gradually becomes burned out. In the United States continuous kilns owing to their cheapness and ease of manipulation are coming into general use for burning common brick but they have not found much favor with pressed brick manufacturers owing to the difficulty experienced in the production of a uniform color to the entire charge of the kiln. Instead of coal dust it is the practice at many of the yards in the southern part of California to use crude petroleum and at one plant in West Virginia producer gas is used.

Paving Bricks.—Several types of clay are used in the manufacture of paving brick but all do not yield equally good results. The varieties employed are surface clays of residual or glacial origin, semi-refractory clays and non-refractory shales. The first of these is used to a limited extent and does not in every case yield good results for it often is siliceous and care has to be taken that it is not calcareous. The semi-refractory clays find favor in many localities but not to such an extent as shales for in nearly every State where the paving brick industry is highly developed it is found that impure shales are the materials most in demand. These shales are commonly obtained from the Carboniferous formation, notably in Ohio, Missouri, Illinois and Indiana, but in New York where the Carboniferous is lacking, Devonian shales are used.

Shales are found especially adapted for the reason that they are fine grained and contain a sufficient quantity of fusible impurities to bring about thorough vitrification at the proper temperature. The following analyses represent the average of 50 shales used in the manufacture of paving brick, 25 of them being from Missouri and 25 from other localities.

Components.	Minimum. %	Maximum. %	Average. %	Components.	Minimum. %	Maximum. %	Average. %
Silica	49·00	75·00	56·00	Lime	0·20	3·50	1·20
Alumina	11·00	25·00	22·50	Magnesia	0·10	3·00	1·40
Ignition loss	3·00	13·00	7·00	Alkalies	1·00	5·50	3·70
Ferric oxide	2·00	9·00	6·70				

From this it may be seen that the percentage of fluxing impurities is quite high and that those usually present are iron oxide, lime, magnesia and alkalies. The iron may be in the condition of either ferric or ferrous oxide. In fact some of it is almost certain to be the latter, and in burning care should be taken to keep

the interior of the kiln supplied with enough air to oxidize the iron thoroughly so as not to lower the fusing points and vitiate the desired results.

A clay that is to be used in the manufacture of paving brick should be of proper composition, and when ground and mixed with water should possess good plasticity, for, as already explained under the molding of brick, clays which are too fat tend to laminate in the stiff-mud machine which is the one mostly employed for molding paving brick. The clay should possess good tensile strength so as to resist tearing when issuing from the die as well as in drying. It should burn to a dense product and the points of incipient fusion and viscosity should be at least 250°F. apart, preferably 400°F. In drying and burning it should not shrink an excessive amount. While clays and shales will naturally vary some in their shrinkage yet in most of the mixtures or single clays that are used the total shrinkage is from 9 to 12%.

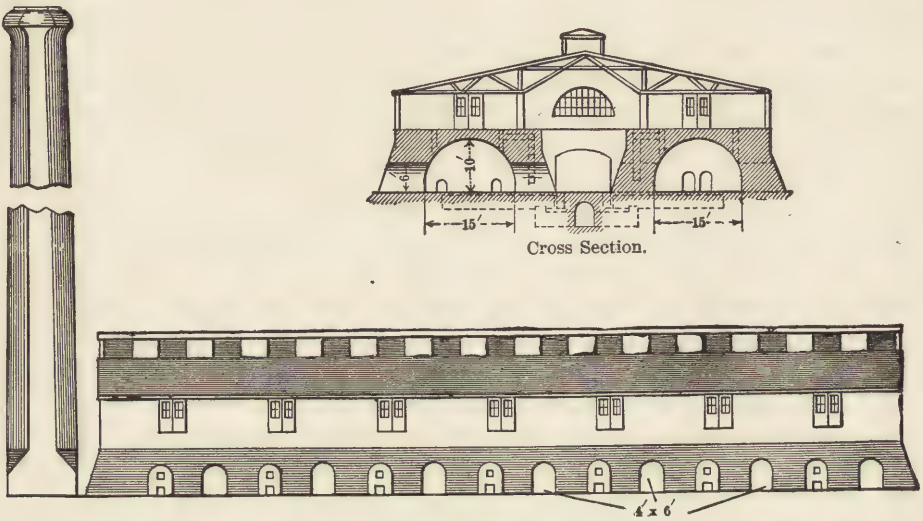
In the manufacture of paving brick the shale is commonly crushed in the dry pan already described, as from its tough nature machinery is required that will break it up cheaply and quickly. Disintegrators are sometimes used but do not work well with hard materials. The clay after grinding should be screened, as much of the proper solidification of the body of the brick in burning depends on the right degree of fineness in the clay. Although the bottom of the dry pan has screen plates it is desirable to carry the material through an additional screen whose fineness should not be less than 8-mesh and preferably 16-mesh. The screens are sometimes barrel shaped, sometimes straight and are set in an inclined position. Although various devices have been invented to help the clay through the screen and prevent the clogging of the meshes, none work in a thoroughly satisfactory manner and an attendant is usually required to watch the sieve and keep the clay from packing. That portion of the clay which does not pass through the sieve is returned to the dry pan.

Paving brick are with few exceptions molded in stiff-mud machines the dies being made for the production of either end-cut or side-cut brick. The latter are probably made in greater quantities. The green brick is often re-pressed in a second special machine shortly after being molded, the object being to smooth the edges and round them off as well as to densify the structure of the brick. It has not yet been definitely settled whether end-cut or side-cut brick are the stronger after re-pressing. The rounding of the corners by re-pressing affords a better foothold to the horses.

The drying of paving brick is nearly always conducted in tunnels in the same manner as with other brick. Burning is done in a variety of kilns. In general the down-draft ones are the most used because they can be better controlled and the greatest heat is obtained in the upper part of the kiln instead of at the bottom. The advantages of this have already been referred to under the caption "Kilns." Of the down-draft kiln two types are used, *viz.*, the round and the rectangular. The round kiln has a capacity of from 40,000 to 80,000 brick and is the favorite one in Ohio. The rectangular one is of more recent type and has a much larger capacity, *viz.*, from 150,000 to 250,000 brick. It is also more convenient to load and discharge.

One of the essentials to success in the manufacture of paving brick is to have

sufficient kilns to receive the product from the machines so that the burning in any one of them need not be hurried. The burning takes from seven to nine days and although the temperature required for vitrification is seldom very high still sufficient time must be allowed to let the brick shrink slowly and also to permit the heat to permeate the entire kiln and reach the center of every brick. After the maximum temperature has been attained the kiln is shut up tight and allowed to remain undisturbed for several days. Upon the slow and careful execution of this part of the process depends to a large extent the toughness of the brick. The clay in burning softens to such an extent that the lower bricks show the impressions of those resting on them. If a draft of cold air gets into the kiln during the cooling of the brick, cracks are produced in them which are usually recognizable by their characteristic lustrous fracture. In the ordinary down-draft kiln a good burner will be able to produce from 80 to 85% of No. 1



Cross Section.

Side Elevation.

FIG. 10.—THE HAIGH NEW SYSTEM BRICK KILN.

pavers but many do not reach this mark. The continuous kiln although the ideal method of burning has not been introduced to any large extent in paving-brick manufacture, partly owing to the fact that the heating of the chambers did not progress evenly and because the high shrinkage of the brick being burned to vitrification made it difficult to maintain the firing holes in the mass. Several manufacturers have tried them with success after adopting them with special modifications. One of the most successful is that of the Haigh type, shown in the accompanying illustrations (Figs. 10 and 11).

TERRA COTTA.—The term terra cotta is used to define those clay products which are used for decorative structural work and are too large to be molded in a machine. This practically means everything over 8 in. square. Pieces below this size are commonly termed ornamental brick. During the last few years the use of terra cotta as a substitute for stone has increased to an unexpected extent so

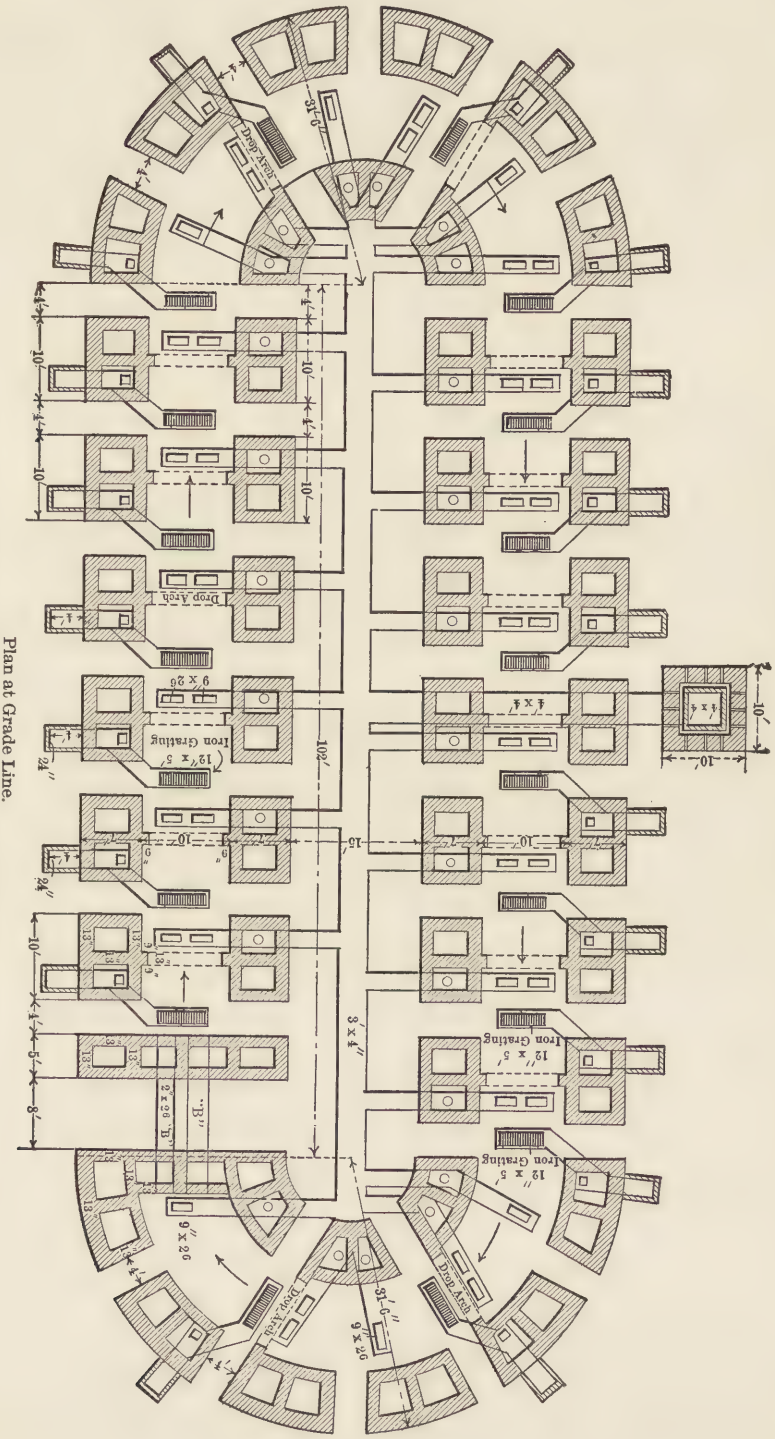


FIG 11.—THE HAIGH NEW SYSTEM BRICK KILN.

that at times there has seemed to be danger of carrying its use to excess. The advantages which are claimed for it over stone are lightness, greater durability, strength, cheapness, greater range of color and greater resistance to fire.

As is the case with building brick the types of clays used vary widely, many of the smaller factories employing lower grades of material so that at times even calcareous ones are used. The tendency at the present time, however, especially among the larger manufacturers, is to use a mixture of semi-refractory clays, which burn to a hard body at a moderate temperature but are not vitrified in actual practice. Analyses of several of them are subjoined.

Components.	Shale from Alfred Center, N. Y.	Shale from Billings, Mo.	Clay from Glens Falls, N. Y.
SiO_2	53·20	63·11	48·35
Al_2O_3	23·25	23·11	11·38
Fe_2O_3	10·99	1·79	4·02
CaO	1·01	0·42	15·38
MgO	0·62	0·70	3·17
Alk	2·69	3·71	6·05
H_2O	6·39	7·05	

It is requisite of a terra cotta clay that it should burn to a hard body at a moderately high temperature, say 2,300°F., producing a product nearly impervious. While vitrification of a clay for this purpose is desirable provided it can be done without too much risk, still the vitrification of a semi-refractory clay such as is generally used means not only the attainment of a rather high temperature and consequent greater consumption of fuel but it is also accompanied with a great shrinkage. This is likely to distort the piece of molded ware especially if its form is at all complex.

The custom therefore is to burn the ware to incipient fusion and then cover it with a slip of dull enamel. This slip covering which is impervious serves a double purpose. It prevents the entrance of moisture into the ware from the exterior and also determines the color of the product, as various artificial or natural coloring compounds are put into it. By this means the architect can get almost any shade that he desires. It rarely happens that one clay alone can be used, consequently two, three, or more up to six clays, are mixed together, while still another ingredient may be added in the form of ground-up fire brick to prevent too much shrinkage of the ware in burning.

The preparation of the clay for manufacture into terra cotta usually consists in grinding it in a dry pan if it is hard, or if soft it is sometimes exposed to the weather. One object of the weathering is to detect the presence of any pyrite or concretions of iron carbonate, both yielding a stain of limonite when exposed to moisture and air. The pyrite may also at times give rise to the formation of a white coating of alum which is a source of annoyance in the burned ware. The ground clays are sometimes tempered in a wet pan and then still further treated in a pug mill attached to an auger stiff-mud machine, the latter having a very large die, so that the clay issues from it as a great bar of square cross-section and is cut into cubical lumps about 8 in. on an edge. These lumps are then piled away in bins until ready for use when they may go through an additional pugging to soften them for molding.

Molding.—This is almost always done by hand. It is first necessary to make a clay model of any object that is molded and around this the plaster mold is formed. If the object is of simple form and not too large the mold can be made in one piece but if the design is complicated and large it is necessary to make the mold in two or three parts. The mold having been made of plaster the workman pushes the pugged clay into all corners and crevices, covering the entire interior of the mold to a depth of about 2 in. When this is accomplished the mold is set aside to dry for four or five hours, and during this time the clay shrinks sufficiently to permit its removal from the plaster form. At the same time it is still soft enough to allow any rough edges to be trimmed off with a knife. When only one piece of a given design is to be made and that of complicated shape, instead of making a mold, it is often customary to make or model the object directly in clay and then burn it. Hand work of this character naturally requires the services of a skilled modeller. These hand-made pieces cannot be dried in the ordinary manner and the moisture in them must be driven off very slowly, the process being even retarded by covering the object with damp cloths during the early part of the drying. If the piece is a very large one it is set in an inclined position during the drying so that in shrinking together it may slip more readily over the sustaining surface.

Drying.—As a rule nearly all terra cotta objects are dried on slat floors heated by steam pipes under them. The drying has to be done very slowly especially in the case of large objects and may occupy a number of days. Large pieces, as a column shaft, are stood first on one end and then on the other, while other objects are turned from one side to the other to facilitate equal shrinkage and drying in all directions. Before going to the kiln the air-dried ware is wheeled to the spraying room, where the slip that is to form the surface coating and the coloring layer is sprayed on it, forming a thin layer over the entire surface of the object and being somewhat absorbed by it. This slip is a mixture of kaolin, quartz, feldspar and coloring ingredients, mixed in the proper proportions to have the same fire shrinkage as the body, thus avoiding its cracking in the kiln.

Burning.—Burning is usually done in down-draft kilns sometimes circular, with a diameter of from 15 to 25 ft., or else rectangular, with a width of about 20 ft. and a length of from 30 to 50 ft. The flames from the fuel enter the kiln through pockets on the inside wall that lead from the fire-places and extend nearly to the top of the chamber. The fire passes next downward through the ware and into flues in the floor which lead it off underneath the kiln to the chimney. Some manufacturers use a muffle kiln which is similar in construction to the circular kiln but differs from it in having a double wall through which the fire passes upward and then down through a central stack. The object of such a kiln is to prevent the flames from coming in contact with the ware and spotting or discoloring it in any way. With few exceptions the fuel used in the burning of terra cotta is coal, although in some regions gas or even oil is used. The total shrinkage of the terra cotta in drying and burning is usually about one-twelfth, or 1 in., to the foot.

In placing the ware in the kiln care has to be taken that none of the pieces have

to bear an excessive weight, which would tend to crush the pieces out of shape. The method found best is to surround the pieces by a framework of slabs of fire clay and grog, thus taking all weight from them. The burning usually occupies from 6 to 8 days and is governed partly by the use of trial pieces covered with Albany slip and partly by Seger cones. Since the clays used in the manufacture of terra cotta vary there is also a variation in the temperature arrived at in different kilns but at those factories which use fire clays and stone-ware clays the maximum temperature is probably from 2,000 to 2,300° F.

After the removal of the ware from the kiln, the pieces of a large design are fitted together properly, being trimmed with a chisel if necessary. At the present time, however, the manufacture of terra cotta has reached such a degree of perfection that the manufacturer is thoroughly familiar with the shrinkage of his clay and if he has a good burner who knows how to regulate the kiln so as to produce an even temperature throughout, there is comparatively little loss from warping and misfits. Terra cotta has been used chiefly for exterior decoration, especially in buildings for business purposes, but with time there is no doubt that it will follow in the path of face brick and tile for interior work also.

Roofing Tile.—The use of roofing tile is far more extended in Europe than in the United States, partly owing to the fact that a proper appreciation is shown for a durable covering for buildings and partly because in many regions wood for shingles or slate is scarce. As a result of this extensive development of the tile working industry many of the European factories turn out tiles in sufficient quantities to supply their own country, and to have large amounts left for exportation. Thus, for example, the roofing tiles manufactured at Marseilles are shipped in large quantities to other ports, even as far as Constantinople. In the United States while burned clay for roofing is still used only to a limited extent, and more for architectural effect than for utility, the progress which has been made during the last ten years is most encouraging.

The clays used in the manufacture of roofing tiles vary widely and include impure surface clays, Devonian and Carboniferous shales, and at times semi-refractory shales. The essential qualities for such a material are, that it shall possess good plasticity, good tensile strength; it should dry and burn without excessive shrinkage, and without warping; it should burn to a dense body and preferably to a good red color. These properties are similar to those required in any clay for the formation of a vitrified ware.

Roofing tiles are made in several different shapes, and each style has its advocates. The common forms are:

Shingle Tile.—These are perfectly flat and of the same shape as a wooden shingle.

Pan Tiles.—These are curved and laid with the arched side alternately up and down so that one overlaps the other.

Interlocking Tiles.—These represent the highest development of the roofing tile and are provided with a series of longitudinal depression on one half and ridges on the opposite side on the other half; the ridges of one tile thus fit into the depressions of the next one below which it overlaps.

There is some dispute among manufacturers as to whether a roofing tile should

be vitrified, or porous and covered with a glaze. The former is perhaps the most desirable and insures a thorough resistance to weather. As regards the shape there is something to be said in favor of each. Interlocking tiles are perhaps the best because from the nature of their shape they fit well and form a tight roof, and consequently do not have to be laid in cement. In order, however, that they do fit properly it is of the highest importance that the clay does not warp in burning. They make the best appearance on a somewhat steep roof, that is one having an angle of about 45°, and do not present a very good effect on a roof of gentle slope. Shingle tile when perfectly straight will also form a good roof. They are well adapted to both a very steep or a very flat surface. Pan tiles are not as tight as shingles and usually have to be laid in cement. The shingle tiles manufactured in the United States are usually vitrified; the interlocking ones are both vitrified and porous, while the pan tiles are porous. The latter named are sometimes salt glazed, although in some cases it is common to cover the tile either with a slip glaze, that is one made from an easily fusible clay or else with an easily fusible lead glaze. This latter practice is very common among European manufacturers and is also carried out to some extent in the United States. There is considerable range in the composition of the glazes used by German roofing tile manufacturers, varying from easily fusible to refractory mixtures. The former would be represented by a mixture of 223 parts of lead oxide and 60 parts of silica; the latter by 294 parts potash, 56 lime, 223 lead oxide, 101 alumina, and 60 silica.*

The more refractory glazes stand the weather better, yet it is a poor plan to use a glaze for any other purpose than adornment.

Since the clays used in the manufacture of tiles must show very even shrinkage in burning, considerable care is taken in the preparation of the raw material. When shales are used many manufacturers grind them to pass through a 22- or even 24-mesh screen. The tempering is sometimes done in a wet pan but usually in a pug mill. Shingle tiles are often molded in an auger stiff-mud machine, the shape of the die being such that the clay issues from it in the form of a ribbon having the proper width and thickness which is cut into proper lengths. Each green tile has to be set on a pallet and taken to the drying racks. There is perhaps nothing which taxes the quality of a clay more than in this process, as it calls for a material of very even character in both its wet and dried condition. Pan tiles may also be molded by the same process. Interlocking tiles have to be treated in a somewhat different manner for the production on the surface of transverse ridges does not permit of passage through a die. The usual method therefore is to run the clay through an auger machine after it is tempered, cutting it up into slabs which are approximately the shape of the tile but somewhat thicker. These slabs are then put into the tile press and given their final form. At the present day the best form of tile press consists of a hexagonal prism (Fig. 12), each face of which forms the under side of the mold, the upper half of the mold being represented by the plunger set in the upper part of the machine. The prism revolves sufficiently each time to bring one of the faces in a horizontal position on top and directly below the plunger. As soon as

* *Clay Worker*, p. 248, 1897.

it reaches this position one of the slabs is laid on it, the plunger descends and the clay slab being pressed between the two faces is shaped into the desired form. The plunger then rises and the prism turns another 60° to receive another slab. As soon as a face with one of the pressed slabs reaches the lowest point of its revolution, the molded tile drops off and is received on a wooden pallet. Since the slab that is set into the mold is larger than the space between the two plates

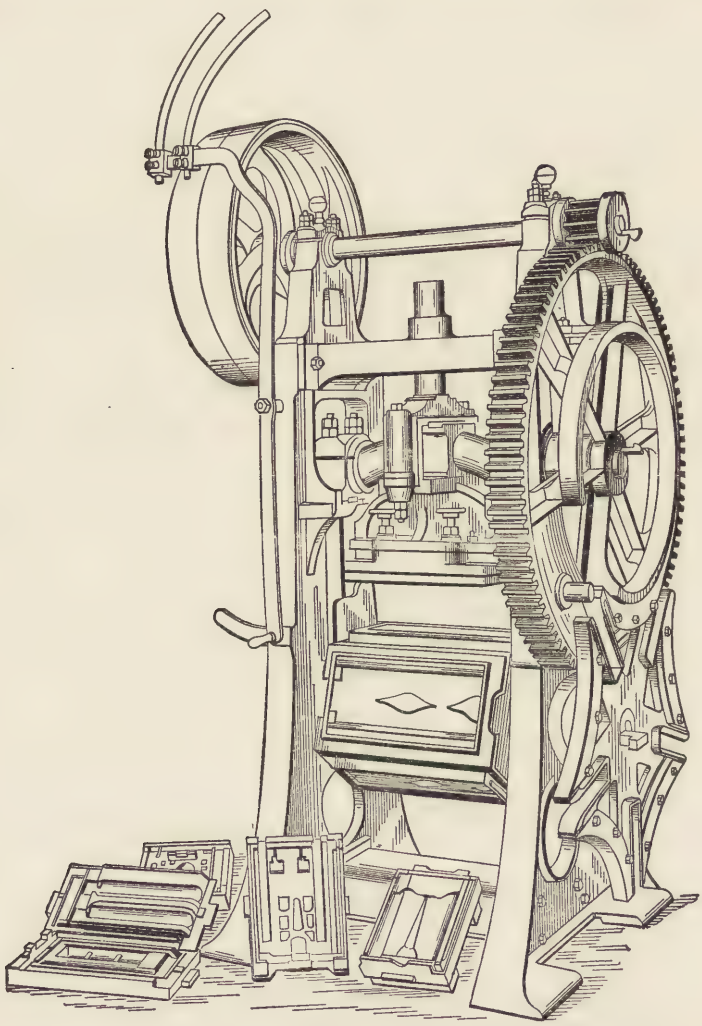


FIG. 12.—ROOFING TILE PRESS.

of the press, provision must be made for the excess of clay to flow out. This causes a flaky edge to be left around the green tile which is trimmed off as soon as it is received on the pallet. This style of machine, first used in Germany and now made in the United States, is perhaps one of the best that has been put on the market. There are, however, two types of mold. One is of plaster, and the other of steel which has to be kept heated or oiled to prevent clay from sticking.

Plaster molds wear out rapidly, requiring replacement, and are not sufficiently strong to permit the clay to be pressed very stiff. The capacity of these roofing tile re-pressing machines varies from 2,000 to 5,000 tile per day.

The tile are received on wooden pallets which conform to the shape of the tile, and are stacked up on shelves in a drying room, or else placed on cars and run through drying tunnels. Various types of kiln are used for burning tile. Formerly in some works the tiles were set in saggers, but now they are usually stood up on edge in the kiln, slabs of fire clay being placed around them for protection against the weight of those above. The production of black tile has been quite extensive in foreign countries but thus far has found but little application in the United States, being opposed partly by the prevailing taste. The method of calling out the black color is very simple and consists in the introduction of some hydrocarbon compound, as tar, into the kiln during the last portion of the burning. The effect of this is to bring about a violent reduction of the iron which turns blue instead of remaining red. Furthermore there is an excess of carbon particles in the kiln, many of which are caught on the surface of the tile. The result is a deep black surface. When this is done it is equally important that all air should be excluded from the kiln during the cooling. The cost of clay tile is not less than slate and sometimes greater. The advantages that clay tiles possess over slate, are greater color range, greater durability, better architectural effect and greater strength. They are, however, more costly on the average and somewhat heavier.

FLOOR TILE.—Two types of floor tile are usually recognized, *viz.*, encaustic tile, and tiles of solid color. In the former the pattern of the tile is formed by a thin layer of different colored clays on the upper surface of the tile. In the latter the tile is of one color which extends through the entire tile. At the present time floor tile are almost without exception made by the dry press process, which is especially necessary in the manufacture of encaustic ones. The clays used vary from easily fusible to highly refractory varieties, generally the latter. In some respects floor tile are subjected to more rigorous conditions than roofing tile, for they have to stand weathering when used out of doors, and resist abrasion as well.

The clays employed for this purpose should therefore burn to a very dense hard body, at a moderate temperature if possible. They should be free from warping in burning, and should resist abrasive action when burned. Kaolin is used to some extent in the cream colored and white tiles, and feldspar is employed at times as a flux. In encaustic tiles there must be absolute adjustment between the clay forming the body and that forming the upper layer of the tile, otherwise the difference in shrinkage will cause the formation of cracks in the mass during the burning. Furthermore it is necessary that the different clays used in encaustic tile should burn to a dense product at the same temperature. This agreement in the behavior of the different clays is accomplished and maintained in part by using materials which agree pretty closely in their rational composition. This necessitates the rational analysis of the raw materials from time to time.*

* "The Ultimate and Rational Analysis of Clays and Their Advantages," by H. Ries, *Transactions of the American Institute of Mining Engineers*, Vol. XXVIII., p. 100.

In the manufacture of floor tiles, the proper results are obtained by using a mixture of clays if necessary, aided by the addition of fluxing materials if the tiles do not burn dense at a sufficiently low temperature. While it is desirable to produce a vitrified body, most tile will show a certain slight absorption at times, the degree of porosity being related somewhat to the color. C. Langenbeck* gives the following figures:

Color of Tile.	Percentage of water absorption by weight.		Color of Tile.	Percentage of water absorption by weight.	
	Extremes. %	Average. %		Extremes. %	Average. %
Salmon	1·5–9·1	5·8	Chocolate	0·0– 7·4	4·8
Buff	1·9–7·2	4·6	Red	1·5– 8·4	6·0
Light gray	1·9–8·5	5·8	Black	4·4–10·3	7·5
Dark gray	2·0–5·8	4·4	Fawn		8·3

Floor tiles are of numerous shapes and by the aid of artificial coloring materials a wide range of shades and colors is also obtained. In the manufacture of plain tiles the powdered material is pressed into steel molds of the proper shape. For encaustic tiles a different process is necessary. In the latter case a steel mold is used having the shape of the tile but two or three times as deep. Into this mold is set a framework of thin brass strips which form the outlines of the pattern that the surface of the tile is to show. The different clays, some containing artificial coloring material, are then strewn in, each color being placed into the proper compartment of the frame. After filling them in to the depth of 0·375 in., the frame is withdrawn and the clay that is to form the body of the tile strewn in over the whole. The mold is then placed in the pressing machine and the powder subjected to great pressure after which the green tile can be removed from the mold. Owing to the great range of colors and the danger of their being damaged if in contact with the flame the tiles are usually burned in saggers which are placed in the kiln in the same manner as in porcelain manufacture.

Sewer Pipe.—The requirements of sewer-pipe clay are somewhat similar to those used for making paving brick or stoneware. The clays used should be sufficiently plastic to permit molding without cracking; they should have a tensile strength of 125 to 150 lb. per sq. in. They should burn to a hard impervious body at a moderate temperature and be of a deep red color after firing. The drying should permit of rapidity during which the clay should not warp or crack. An excess of fluxing impurities may make a clay soften to such an extent as to lose its shape in burning. While surface clays are used to some extent the material employed at most localities is a shale. In New York the Devonian shales are drawn upon, while in Ohio, Indiana, and Missouri, the Carboniferous shales make an excellent grade of raw material. The shales are ground in a pan, and tempered in a dry pan or in a chaser mill, which is similar to a dry pan but has light and very narrow wheels instead of broad and heavy ones. They revolve rapidly and travel from the center to the circumference of the pan very much after the manner of a ring-pit wheel. They are quite thorough in their action. The tempered clay is taken to the upper story of the factory usually by means

* "Chemistry of Pottery," p. 156.

of a bucket elevator and discharged into the pipe press. The press consists of two cylinders, the upper called the steam cylinder and the lower the clay cylinder. The lower cylinder is filled with clay which is forced down by a piston actuated by a second one in the overlying steam cylinder, the two being on a common piston rod. The clay is forced out through the die in the bottom of the cylinder. When the sewer pipe has issued to a sufficient distance the machine is stopped, the pipe cut off, and the section received on a pallet as it leaves the machine. The pipe is sometimes cut off by means of a wire but the more modern machines have a cutting knife located inside of the die. Before the pipe is set on the drying floor the edges are trimmed. Small diameter pipe can be dried very rapidly, but larger ones have to be treated with great care, sometimes several weeks elapsing before they can be set in the kiln. Sewer pipes are nearly always burned in circular down-draft kilns and, owing to the thinness of the ware, the burning can proceed with comparative rapidity. The surface is commonly glazed with salt, which is done by adding it to the fire near the end of the burn. The salt vapors produced pass up through the kiln and unite with the silica of the clay, forming a thin glaze on the pipe surface. Sewer pipe should be free from blisters, cracks and warping.

COAL AND COKE.

THE continued industrial prosperity in the United States during 1900 has resulted in increased production of coal, the year's output surpassing the record figures of 1899. Comparing the two years the production in 1900 was 243,414,163 metric tons (268,315,433 short tons) as against 228,717,579 metric tons (252,115,387 short tons) in 1899. The total production of the chief countries in the world during 1900 will doubtless exceed even the enormous total of 1899, the increase for the most part coming from the United States. The world's production for 1899 was 723,617,836 metric tons as against 665,413,558 metric tons in

TOTAL PRODUCTION OF COAL IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

Statcs.	1899.			1900.		
	Tons.	Value at Mine.		Tons.	Value at Mine.	
		Total.	Per Ton		Total.	Per Ton.
Bituminous:						
Alabama	7,484,763	$7,484,763	$1·00	8,504,327	$10,205,192	$1·20
Alaska (*b*)	2,300	12,282	5·34	2,600	14,950	5·75
Arkansas	*a*913,743	1,233,553	1·35	*a* 1,250,000	1,687,500	1·35
California	167,161	430,631	2·58	177,515	485,126	2·73
Colorado (*e*)	4,747,812	8,308,671	1·75	5,436,490	10,872,980	2·00
Georgia	203,775	183,081	0·90	248,000	260.050	1·04
Illinois	*a*23,434,445	18,443,946	0·78	*a*25,153.929	22,510.360	0·89
Indiana	6,158,224	5,542,402	0·90	6,357,976	6,675,875	1·05
Indian Territory	*a*1,404,442	2,106,663	1·50	*a*1,900,127	3,534,236	1·86
Iowa	4,675,000	5,937,350	1·27	5,089,651	6,968,866	1·37
Kansas	4,096,895	5,124,248	1·25	4,507,201	5,634,001	1·25
Kentucky	4,668,800	3,720,100	0·80	4,991,204	3,908,113	0·78
Maryland	5,080,248	4,318,211	0·85	3,923,808	4,198,475	1·07
Michigan	500,000	720,000	1·44	843,476	1,307,388	1·55
Missouri	*a*3,191,811	3,582,111	1·12	*a*2,995,022	3,643,975	1·21
Montana	1,409,882	2,227,998	1·58	1,705,957	2,968,365	1·74
Nebraska (*d*)	1,000	3,000	3·00	900	2,500	2·78
New Mexico (*d*)	*a*1,004,034	1,495,588	1·49	*a*1,145,739	1,722,780	1·50
North Carolina	26,994	37,792	1·40	17,744	22,180	1·25
North Dakota (*b*)	120,597	120,597	1·00	162,929	171,075	1·05
Ohio	16,695,949	14,191,557	0·85	20,671,254	20,257,829	0·98
Oregon	86,886	232,854	2·68	51,050	135,640	2·66
Pennsylvania	73,066,943	57,722,885	0·79	79,318,362	77,731,995	0·98
Tennessee	3,736,134	3,706,617	0·99	3,904,048	4,294,928	1·10
Texas (*c*)	940,622	1,646,088	1·75	1,022,827	1,871,773	1·83
Utah	882,496	1,553,193	1·76	1,233.978	2,443,276	1·98
Virginia	2,111,391	1,372,404	0·65	2,504,974	2,179,327	0·87
Washington (*d*)	1,917,607	3,355,812	1·75	2,418,034	4,425,002	1·83
West Virginia	*a*18,201,189	11,830,773	0·65	*a*21,153,340	14,165,183	0·67
Wyoming	4,525,207	5,656,509	1·25	4,129,265	5,161,581	1·25
Total bituminous (Sh. tons)	191,456,350	$172,301,679	$0·90	210,821,727	$219,460,521	$1·04
Total bituminous (Met. tons)	173,688,061		0·99	191,256,216		1·15
Cannel: Kentucky (Sh. tons)	36,639	$91,597	$2·50	29,471	$88,413	$3·00
Cannel: Kentucky (Met. tons)	33,239		2·76	26,736		3·31
Anthracite:						
Colorado	59,067	$162,434	$2·75	59,244	$177,732	$3·00
New Mexico	*a*45,000	105,000	2·33	*a*41,595	114,385	2·75
Pennsylvania	60,518,331	103,486,346	1·71	57,363,396	102,680,479	1·79
Total anthracite (Sh. tons)	60,622,398	$103,753,780	$1·71	57,464,235	$102,972,526	$1·79
Total anthracite (Met. tons)	54,996,279		1·89	52,131,212		1·97
Grand total coal (Sh. tons)	252,115,387	$276,147,056	$1·10	268,315,433	$322,521,530	$1·20
Grand total coal (Met. tons)	228,717,579		1·21	243,414,163		1·32

(*a*) Fiscal year. (*b*) All lignite. (*c*) One-third lignite. (*d*) One-half lignite. (*e*) One-seventh lignite.

TOTAL PRODUCTION OF COKE IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1899.			1900.		
	Tons.	Value at Oven.		Tons.	Value at Oven.	
		Total.	Per Ton.		Total.	Per Ton.
Alabama	1,798,612	$4,676,391	$2·60	1,992,561	$6,376,195	$3·20
Colorado	455,783	1,253,403	2·75	575,447	1,726,341	3·00
Georgia	44,529	92,748	2·08	72,000	212,640	2·95
Illinois	2,000	3,300	1·65	1,800	4,290	2·38
Indiana	2,105	4,105	1·95	1,249	3,122	2·50
Indian Territory	(*a*) 29,362	95,426	3·25	*a* 47,800	184,030	3·85
Kansas	200,000	600,000	3·00	275,000	618,750	2·25
Kentucky	55,580	79,201	1·42	72,975	158,389	2·17
Missouri	4,560	8,803	1·93	2,368	6,022	2·54
Montana	59,072	401,779	6·80	54,697	318,789	5·83
New Mexico	(*a*) 33,661	110,046	3·27	*a* 42,803	139,966	3·27
Ohio	73,391	183,477	2·50	48,648	132,809	2·73
Pennsylvania (*c*)	12,192,570	29,871,796	2·45	12,189,912	32,912,762	2·70
Tennessee	440,157	864,073	1·91	494,438	1,186,655	2·40
Utah	26,700	122,820	4·60	35,013	168,763	4·82
Virginia	555,507	1,027,688	1·85	651,578	1,348,766	2·07
Washington	31,283	117,311	3·75	35,921	176,013	4·90
West Virginia (*b*)	(*a*) 2,058,378	2,580,175	1·25	*a* 2,598,283	4,546,995	1·75
Wyoming	15,979	55,926	3·50	14,501	50,573	3·50
Total coke { Short tons	18,079;329	$42,148,468	$2·33	19,206,994	$50,272,050	$2·62
Total coke { Metric tons	16,401,369		2·57	17,424,471		2·89

(*a*) Fiscal year. (*b*) Includes 40,537 tons made in Wisconsin in 1899, and 37,436 tons made in 1900; also, 53,973 tons made in Virginia in 1899, and 64,740 tons in 1900. (*c*) Includes 4,800 tons made in Wisconsin in 1900.

UNITED STATES PRODUCTION OF COAL, 1896-1900. (IN TONS OF 2,000 LB.)

Year.	Alabama.	Arkansas	California.	Colorado.	Georgia.	Illinois.	Indiana.	Indian Territory	Iowa.	Kansas.
1896	5,747,698	889,750	70,649	3,371,633	246,012	*a*19,786,626	*a*4,068,124	1,235,333	4,115,000	3,191,748
1897	5,893,771	850,000	87,449	3,565,660	196,268	*a*20,072,758	4,439,489	*a*1,343,376	4,523,494	3,672,195
1898	6,466,741	*a*1,134,064	135,795	4,174,037	240,000	*a*18,599,299	5,435,896	*a*1,458,098	4,117,359	3,860,405
1899	7,484,763	*a*913,743	167,161	4,806,879	203,775	*a*23,434,445	6,158,224	*a*1,404,442	4,675,000	4,096,895
1900	8,504,327	*a*1,250,000	177,515	5,495,734	248,000	*a*25,153,929	6,357,976	*a*1,900,127	5,089,651	4,507,201

Year.	Kentucky	Maryland	Michigan	Missouri.	Montana.	Nebraska.	New Mexico.	North Carolina.	North Dakota.	Ohio.
1896	3,128,818	4,062,716	85,465	*a*2,420,147	*a*1,157,722		655,370	14,970	94,500	12,912,608
1897	3,304,053	4,411,924	152,850	*a*2,429,388	*a*1,607,637	500	*a*729,653	20,611	120,000	12,465,533
1898	3,542,132	4,621,618	378,541	*a*2,838,152	1,450,971	500	*a*863,583	6,144	124,526	14,053,829
1899	4,705,439	5,080,248	500,000	*a*3,191,811	1,409,882	1,000	*a*1,049,034	26,994	120,597	16,695,949
1900	5,020,675	3,923,808	843,476	*a*2,995,022	1,705,957	900	*a*1,187,334	17,744	162,929	20,671,254

Year	Oregon	Pennsylvania.		Tennessee.	Texas.	Utah.	Virginia	Washington.	West Virginia.	Wyoming	Totals. (*b*)
		Bituminous.	Anthracite.								
1896	90,715	50,273,656	48,074,330	2,663,714	585,000	503,243	1,018,237	1,295,313	13,509,964	2,273,928	187,657,250
1897	100,929	54,674,272	52,581,036	2,888,849	615,540	506,455	1,418,746	1,489,815	13,950,000	2,744,960	200,857,211
1898	65,871	64,247,859	52,799,774	3,084,748	751,191	571,417	1,640,000	1,988,288	16,499,840	3,181,905	218,333,883
1899	86,886	73,066,943	60,518,331	3,736,134	940,622	882,496	2,111,391	1,917,607	*a*18,201,189	4,525,207	252,115,387
1900	51,050	79,318,362	57,363,396	3,904,048	1,022,827	1,233,978	2,504,974	2,418,034	*a*21,153,340	4,129,265	268,315,433

(*a*) Fiscal year. (*b*) Includes from Alaska, 1,300 in 1898, 2,300 in 1899, and 2,600 in 1900.

IMPORTS OF COAL AND COKE INTO THE UNITED STATES. (IN LONG TONS.)

Year.	Coal.					Coke.		
	Anthracite.	Bituminous	Totals.			Long Tons.	Metric Tons	Value.
	Long Tons.	Long Tons.	Long Tons.	Metric Tons	Value.			
1896	101,689	1,246,991	1,348,680	1,370,259	$3,725,832	43,372	44,066	$114,713
1897	3,281	1,276,963	1,280,244	1,300,728	3,432,154	35,193	35,756	98,558
1898	3,149	1,270,557	1,273,706	1,294,085	3,578,181	41,185	41,844	142,334
1899	61	1,400,461	1,400,522	1,422,930	3,882,675	27,855	28,301	142,504
1900	118	1,909,258	1,909,376	1,939,926	5,020,102	103,175	104,826	371,341

EXPORTS OF COAL AND COKE OF DOMESTIC PRODUCTION. (IN LONG TONS.)

Year.	Anthracite.		Bituminous.		Totals.		Coke.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1896.....	1,350,000	$5,925,506	2,276,202	$5,072,818	3,626,202	$10,998,324	151,062	$553,600
1897.....	1,298,768	5,836,730	2,399,263	5,326,761	3,698,031	11,163,491	173,034	546,066
1898.....	1,350,948	5,712,985	3,152,457	6,699,248	4,503,405	12,412,233	199,562	600,931
1899.....	1,707,796	7,140,100	4,044,354	8,573,276	5,752,150	15,713,376	280,196	858,856
1900.....	1,662,286	7,107,412	6,255,033	14,416,667	7,917,319	21,524,079	376,999	1,358,968

PRODUCTION AND CONSUMPTION OF COAL IN THE UNITED STATES. (IN LONG TONS.)

Year.	Production.	Imports.	Total Supply.	Exports.		Consumption.	
				Domestic.	Foreign.	Tons.	Metric Tons.
1896.....	167,551,116	1,348,680	168,899,796	3,626,202	5,204	165,268,390	167,912,684
1897.....	179,336,796	1,280,244	180,617,040	3,698,031	5,297	176,913,712	179,744,331
1898.....	194,940,967	1,273,706	196,214,673	4,503,405	2,890	191,708,378	194,775,712
1899.....	225,103,024	1,400,522	226,503,546	5,752,150	6,806	220,744,590	224,276,503
1900.....	239,567,351	1,909,376	241,476,727	7,917,319	6,740	233,552,668	237,289,511

The coal mining industry in the United States progressed very favorably during 1900 and, although the industrial activity was less pronounced than in 1899, the market was steady at profitable figures for all coal produced. The year was characterized by two prolonged strikes, one in the anthracite regions in Pennsylvania—the largest on record so far as the number of strikers is concerned—and the other in the Georges Creek field in Maryland which lasted much longer but involved fewer men. There were also a few minor labor disturbances in the South and in the Rocky Mountain country. The tendency toward the consolidation of mining and carrying interests, culminated toward the close of 1900 in the control of the anthracite trade by Morgan and Vanderbilt interests, details of which are given later in this section.

The appended diagrammatic chart given on page 143 illustrates clearly the relative positions of the different coal producing countries and shows that the United States may now be regarded as the greatest coal producing country in the world—a position it bids fair to occupy for many years to come.

Alabama.—Owing to the continued prosperity in the iron industry of the South, as well as in other manufacturing lines there was an increase in the production of coal in 1900 over that of 1899, the statistics being respectively 8,504,327 short tons and 7,484,763 tons.

Illinois.—The production of coal for the fiscal year ending June 30, 1900, was 25,153,929 short tons as compared with 23,434,445 short tons in 1899. Although this increase is not as proportionately great as in some other States, Illinois still maintains the position of second on the list of coal producers.

Maryland.—The production of coal in 1900 was 3,923,808 short tons as compared with 5,080,248 short tons in 1899. The decrease was caused by the protracted strike in the Georges Creek region which stopped shipments for four months beginning April 12. The strike was induced by the United Mine

Workers, who endeavored to force a recognition of their organization but without success.

Ohio.—There was a large increase in the production of coal during 1900, the total being 20,671,254 short tons as compared with 16,695,949 short tons in 1899. The increase has been mainly due to the use of a greater number of mining machines and the freedom from labor troubles.

Pennsylvania.—This State continues to be the largest producer and although badly handicapped by the serious strike in the anthracite fields, the production in 1900 amounted to 79,318,362 short tons of bituminous coal and 57,363,396 short tons of anthracite coal as compared with 73,066,943 tons of bituminous coal and 60,518,331 tons of anthracite. The total coal production for 1900 was 136,681,758 short tons, as against 133,585,274 short tons, a net increase of 3,096,484 short tons. The strike was primarily brought about to force a recognition of the United Mine Workers—an organization that had heretofore confined its operations to the bituminous coal fields—and began September 18. Coal production was almost completely stopped in the Wyoming and Lackawanna fields and greatly retarded in the Lehigh and Schuylkill regions. The strike lasted six weeks and toward the last involved 130,000 men and boys. The bituminous fields in the State were extremely active owing to the strike in Maryland and the mines shipping to tidewater found their product in great demand which resulted in a phenomenal output. Coal consumption in the Pittsburg region fell off in the latter half of the year as well as the production of coke in the Connellsville district, but the decrease was not sufficient to keep the total output from being the heaviest yet recorded.

PENNSYLVANIA SHIPMENTS AND PRODUCTION OF ANTHRACITE COAL. (IN LONG TONS.)

Companies.	1897.		1898.		1899.		1900.	
	Tons.	%	Tons.	%	Tons.	%	Tons.	%
Philadelphia & Reading	8,395,411	20·2	8,219,814	19·6	9,683,503	20·3	9,338,516	20·7
Lehigh Valley	6,425,227	15·4	6,885,577	16·5	7,588,932	15·9	6,909,442	15·3
Central of New Jersey	4,730,860	11·4	4,626,386	11·0	5,392,550	11·1	5,309,856	11·8
Delaware, Lackawanna & Western	5,690,684	13·7	5,795,540	13·8	6,372,401	13·5	6,013,849	13·3
Pennsylvania Coal Co	1,777,841	4·3	1,854,515	4·4	2,347,061	4·9	2,090,153	4·7
Delaware, Hudson & Lackawanna	5,646,853	13·5	5,613,186	13·4	6,430,050	13·6	6,228,770	13·8
Other lines	8,970,988	21·5	8,904,733	21·3	9,850,706	20·7	9,216,898	20·4
Total shipments	41,637,864	100·0	41,899,751	100·0	47,665,203	100·0	45,107,484	100·0
Used and sold at mines	5,309,490		5,242,904		6,369,021		6,109,834	
Total production, long tons	46,947,354		47,142,655		54,034,224		51,217,318	
Total production, short tons	52,581,036		52,799,774		60,518,331		57,363,396	
Total production, metric tons	47,698,512		47,896,937		54,898,772		52,036,795	

West Virginia.—This State is now in third place on the list of producers and in 1900 yielded 21,153,340 short tons as compared with 18,201,189 tons in 1899. The operators in the regions shipping to tidewater profited by the strike in Maryland and shipped a very large output. Due to favorable industrial conditions, new mining companies have been formed and a very large amount of capital has been invested in coal lands during the past two years. The influx of miners from the mines in the Pittsburg district that were purchased by consolidations has continued and operators have found a ready market for their

product in the Central States and in the Lake trade. Toward the end of 1900 the New River and Kanawha Coal Co. was incorporated, which will control at least 95% of the output of bituminous coal in this State.

Other States.—There were increased productions in nearly all of the States not particularized above, although labor trouble in Kentucky and Tennessee curtailed the output. In the West and Northwest, coal mining was very active during the year, as the smelters were generally very busy, which increased the demand for coal. North Dakota showed considerable activity in the mining of lignite near Bismarck. The fearful dust explosion on April 28 at the Castle Gate mines in Utah reduced the production from this State. The accident resulted in the loss of 242 men, mainly by suffocation. In California the discovery of extensive oil fields in the southern and central parts of the State has had a dampening effect on the development of the coal mining industry and even in the present initial development of the fields, oil is a considerably cheaper fuel than coal.

Exports and Imports.—There was a large increase in the exports of coal during 1900, and apart from Canada and Mexico which naturally derive a large part of their supply from the United States, there was a noteworthy gain in the amount shipped to Europe, which was 635,273 long tons, against 35,322 long tons in 1899. The greater part of this was taken by France. The scarcity and high price of coal in England made it possible to place American coal in Mediterranean ports at comparatively low prices notwithstanding the high ocean freight rates. The imports were derived chiefly from Canada, 75% of which came from British Columbia and was used on the Pacific Coast, while the remaining 25% came from Nova Scotia and was used at the New England Gas & Coke Co.'s plant near Boston. Our coal imports are not an important factor of the trade outside of California. The following table shows the division of the exports and imports of coal in 1899 and 1900.

UNITED STATES EXPORTS AND IMPORTS OF COAL CLASSIFIED AS TO COUNTRIES.

Country.	Exports.		Imports.	
	1899.	1900.	1899.	1900.
Australasia	*Nil.*	*Nil.*	146,933	254,183
Canada	4,376,287	5,422,493	1,010,700	1,484,576
Central and South America	94,279	223,795		
Europe	35,322	635,237	126,692	118,987
Hawaii and Philippine Islands	89,309	96,870	*Nil.*	*Nil.*
Japan	*Nil.*	*Nil.*	12,715	9,045
Mexico	560,069	664,036	103,014	41,326
West Indies	581,614	760,879	*Nil.*	*Nil.*
Others	15,280	114,009	407	1,141
Totals	5,752,150	7,917,319	1,400,461	1,909,258

Production of Coal in the Chief Countries in the World.

The total production of coal in the world during 1899 amounted to 723,617,836 metric tons, as compared with 665,413,558 tons in 1898. Detailed statistics are given in the subjoined table.

COAL PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

Year.	Africa.	Australasia.					Austria-Hungary	Belgium.	Canada.		France.	Germany.
		New South Wales.	New Zealand.	Queensland.	Tasmania	Victoria.			Alberta, British Colu'bia	N. Brunsw'k, Nova Scotia.		
1895	1,402,182	3,500,000	760,000	275,000	33,000	204,000	27,250,000	20,414,849	1,403,911	1.782,732	28,236,039	103,957,639
1896	1,787,908	3,972,068	805,537	377,322	44,286	230,187	33,676,411	21,252,370	1,138,682	2,259,168	29,190,000	111,471,106
1897	2,003,174	4,453,728	854,164	364,142	43,210	240,053	35,939,416	21,492,446	1,178,010	2,383,567	30,798,000	120,474,485
1898	a2,550,485	4,781,551	921,546	414,461	49,902	246,845	37,785,962	22,088,335	1,461,862	2,323,546	32,356,107	127,958,550
1899	b 239,443	4,670,580	990,838	501,913	43,803	266,578	38,738,372	22,072,068	1,448,560	2,693,682	32,862,712	135,844,419

Year.	India.	Italy.	Japan.	Russia. (f)	Spain.	Sweden	United Kingdom.	United States.	All Other Countries	Totals.
1895..	2,650,000	250,000	4,843,936	9,098,477	1,774,560	205,000	194,350,604	177,595,679	1,750,000	580,186,311
1896..	3,909.582	276,197	5,100,005	9,377,551	1,852,947	225,848	198,487,040	170,242.657	e2,000,000	597,676,866
1897..	4,128,137	314,222	5,647,751	11,203,738	2,019,000	224,343	205,364,010	182,216,466	e2,000,000	633,342,072
1898..	4,678.640	341,327	6,651,208	12,241.574	2,466,800	236,277	205,287,388	198,071,199	e2,500,000	665,413,558
1899..	5.016,055	388,534	6,721,798	12,800,000	2,600,279	239,344	223,616,279	228,717,579	e2,500,000	723,617,836

(a) Includes estimate of 50,000 tons as the output of the Orange Free State, for which no statistics are available. (b) The production of Transvaal and Orange Free State is estimated at 50,000 tons. (e) Estimated. (f) 1899 production estimated.

Canada.—On the Atlantic seaboard the collieries of the Dominion Coal Co., on Cape Breton, had a busy year, and the output of all the Nova Scotia mines in 1900 amounted to 3,013,638 tons, an increase of 14% over the production in 1899. The Dominion Iron and Steel Co., at Sydney, consumed a large part of the yield, and the outlook for coal mining is very encouraging. The local demand for coal was so great during the year as to retard the growing movement to the United States which was so prominent a feature of the 1899 trade. The collieries and coke ovens at Fernie, B. C., that started work in 1899, found a ready market for their total output among the mines and smelters in surrounding districts, and the plant is to be further enlarged, while new collieries will probably be opened in the same region. The coal mines on Vancouver Island and on the west coast, owing to the Alaskan trade and the general increase in shipping from Pacific Coast ports, had an excellent year and their output should show a substantial increase. In the Northwest Territory some fair grade lignite beds have been opened near Dawson.

Mexico.—In Mexico large sums of money have been spent in exploring for coal, but not with satisfactory results as yet, and the lack of adequate fuel supply is likely to handicap the country's industrial development. The Southern Pacific Railroad has conducted extensive explorations in Sonora, where a limited field of fair quality coal lying in this bed has been known to exist for some time. The production of coal in 1900 was 389,977 metric tons, as against 409,125 tons in 1899.

South America.—In respect of the development of coal mines South America maintains its inert attitude. There are good deposits of coal known in Peru and in Colombia, but there is no probability of these deposits being developed through native inception. In Argentina where foreign blood predominates, and in Chile, industrial activity continues and the output of coal, when the figures are rendered, will doubtless show a gain. The imports of coal into Chile are shown in the table on the following page, reported in long tons, for which we are indebted to the courtesy of Jackson Bros., of Valparaiso:

Year.	Steam Coal.						Smelting Coal.		
	Hartley.	Orrell.	Other Classes.	Australian.	North American.	Total.	English.	Australian.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1896.....	151,547	9,254	115,024	290,073		565,898	14,889	38,186	53,075
1897.....	126,909		52,979	296,173		476,061	7,646	50,172	57,818
1898.....	134,177	8,591	100,480	270,085	10,608	523,941	8,599	42,763	51,362
1899.....	125,042	7,633	151,325	307,119	3,200	594,319	24,073	43,277	67,350
1900.....	88,655	10,341	121,284	356,859	35,600	612,739	15,657	45,350	62,007

Europe.—In Europe the search for new coal fields has continued with little success, though there are reports of recent finds of value in southeastern Europe. In western Europe, where coal is most wanted, there has been little new coal found.

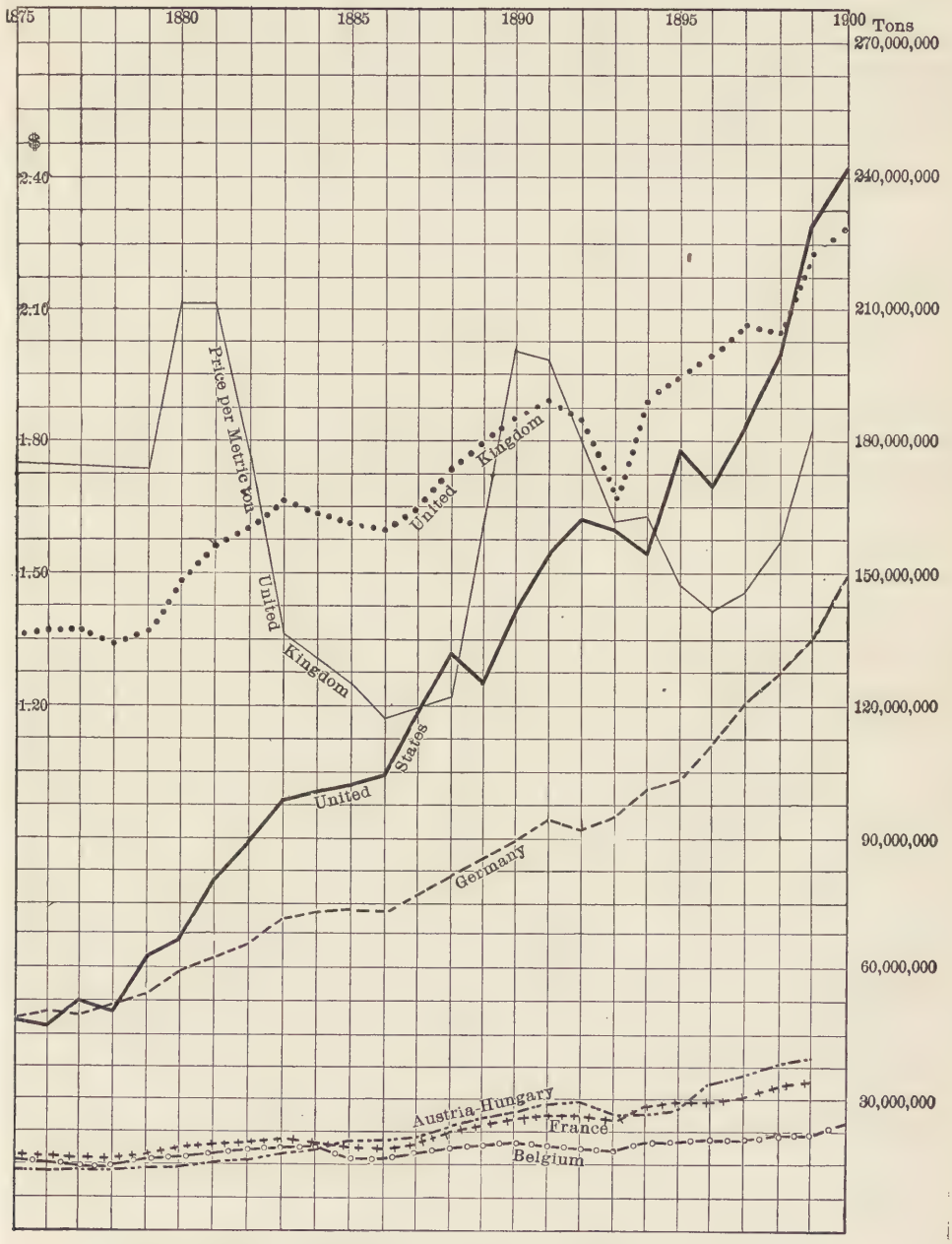
In England the coal production of 1900 was 225,181,300 long tons. There were no strikes or serious interferences with production at the English collieries and the small percentage of gain over the output of the year previous is therefore very noticeable. The competition of American coal may have affected English export trade somewhat, though, owing to the high freight rates from this side and the difficulties attending the introduction of a new fuel, American competition was not seriously felt by English mine owners. There was a good demand in France and a fair one in Germany for English coal, though exports to other countries, notably South America, felt American competition more severely. The price of coal during the greater part of the year was high enough to give every inducement to colliery owners, and the comparatively small increase in production is therefore the more apparent. The Welsh mines, which supply the export trade, doubtless felt American competition somewhat, and also were affected by military operations in South Africa and China, which removed from regular service a large fleet of steamers which, if employed in trade, would have used more coal.

In Belgium coal mining has been very active with high prices stimulating output. The production during 1900 amounted to 23,352,352 metric tons as compared with 22,072,068 tons in 1899.

The French coal output in 1900 was 33,270,385 metric tons, a slight increase over the production in 1899, which amounted to 32,862,712 metric tons. Coal was scarce in France during the whole year, and at its close prices had risen to very high figures, the commodity retailing as high as $15 per metric ton at Paris.

The industrial crisis in Germany in 1900 affected the demand for coal, but the total production for the year was not materially affected. The production in 1900 was 149,551,058 metric tons and in 1899 was 135,844,419 metric tons. The percentage of increase in the output of the lignite mines is noticeable, being nearly 20%. Austria-Hungary showed a decrease in output, due to a bitter and prolonged strike in the Bohemia brown coal fields, which affected coal mining all over upper Austria and Moravia. The reduction of output made coal high in Austria during the year and greatly stimulated shipments of American coal to Trieste.

Of the great coal producing countries of the world Russia, when the full



THE WORLD'S PRODUCTION OF COAL IN METRIC TONS

statistics are made up, will undoubtedly show an increase for the year 1900, this increase coming mostly from the mines of Donetz Basin in southwestern Russia. The mines in Poland have worked steadily, but their production did not differ very much from that of 1899. The total production of Russia in 1899 was 12,800,000 metric tons, and for the first half of 1900, 7,806,455 tons.

Spain.—The production of coal in Spain during 1900 was 2,680,193 metric tons as against 2,600,279 in 1899; the production of lignite in 1900, not included in the above figures, was 92,444 metric tons, as against 70,195 metric tons in 1899.

In Asia there was far less work done in opening new fields than was promised the year before. Although the Russian Government has done considerable work in Central Siberia along the line of the Trans-Siberian Railroad, and also in Eastern Siberia at the mines on the Island of Saghalin and west of Vladivostok, all industrial activity in Eastern Asia has mainly been at a standstill during the last half of the year on account of the situation in China. In that country, where wretched government has prevented the development of great natural resources, the uprising against foreigners completely stopped whatever mining operations were under way in the disturbed provinces and interfered with industry generally. The Japanese mines, the largest producers in the East, found their product in demand throughout the year. These mines are being equipped with the best mining devices, and new ones that are being opened, will be operated in conformity with the most approved modern practice.

In the Australian colonies production was heavy, though probably it did not much exceed that of the year before, owing to the difficulty the operators constantly have in getting miners for their works. In the principal coal producing colony, New South Wales, the miners' union, which wholly controls the labor situation, effectually prevents the output from increasing in response to increased demand.

In Africa, though the British forces occupied the capitals of the Free State and the Transvaal, the Boer forces still in the field made it impossible for the Witwatersrand gold mines to resume working. Indeed in practically all South Africa military exigencies govern, and commerce and manufacturing must wait. Some of the mines supplying the railroads have been worked by the British forces, but otherwise coal production has amounted to nothing.

Borneo.—In British Borneo the only mines worked are at Muara, which export about 14,000 tons of coal annually. Coal is worked in the Island of Labuan, and its harbor is now an important coaling station. The output of coal in 1897 was 35,400 metric tons, valued at £18,536. The coal is very suitable for steamships and it is used for tin smelting at Singapore. In Sarawak the Government works coal mines at Sadong and Brooketon, which localities respectively produce about 40,000 tons and 12,000 tons a year.

The Anthracite Coal Trade in 1900.

The year 1900 was on the whole the most noteworthy year in the history of the anthracite industry. For the first time since hard coal shipments on any

considerable scale began, the various mining concerns restricted output to market needs and refrained from unprofitable competition. The year would have shown the greatest production in the history of anthracite mining but for the strikes of mine employees in September and October—and this was memorable both from the great number of men who stopped work and from the fact of its being the only successful large strike that has ever occurred in the anthracite region. The miners secured substantial concessions and the close of the strike found them more firmly organized than ever before. The results of these two great movements—the concentration of mine ownership and the organization of mine labor—occurring in the same year, are indicated in better wages and steadier employment of the miners, in profits for the mining and transportation companies and in higher prices for anthracite coal.

As the railroad companies which transport the coal from the mines to market are also interested in coal mining, they are the controlling factor in production. The definite change from the old policy of reckless competition between these companies began in 1898 when the house of J. P. Morgan & Co., already a large holder of anthracite securities, began to increase its holdings and to work for a systematic control of output. In 1899 the Pennsylvania and the New York Central Railroads came to an understanding under which the Pennsylvania was to control the seaboard bituminous trade and the Central to take a larger interest in anthracite. The house of J. P. Morgan & Co. continued its aggressive policy, buying out the independent companies until by the purchase of the Pennsylvania Coal Co. last year, followed by purchases of collieries by the Delaware & Hudson Railroad, the Morgan and Vanderbilt interests came into full control of the anthracite trade. An effect of these great combinations was the general absence, in 1900, of cutting of prices and breaking of agreements, and the year in the coal traffic was marked by harmony and a firm control of the output.

January, 1900, opened with good prospects throughout the anthracite coal region and during the last half of the month and the first half of February, the Schuylkill collieries paid the highest wages recorded in 12 years. The January output was 4,455,000 tons, the best for any January on record, and the February output was 3,198,000 tons. March opened cold and its output of 3,736,895 tons was mostly consumed, while prices remained firm. In April there was a considerable slump in prices of hard coal, and during May and June business was very quiet. At the end of June the anthracite product for the first half of the year was 23,136,268 tons, an increase of 2,445,170 tons over the first half of 1899. In June a cargo of 3,500 tons was shipped from Philadelphia to Kronstadt, Russia, the first shipment of anthracite ever made to a European port. By the middle of August, with the likelihood of a September strike at the mines, buying took on more activity in spite of the weather. The mining companies, in anticipation of trouble, moved work briskly at the collieries, and the total output for the year to September 1, was 31,635,984 tons, the largest amount of coal ever shipped from the collieries in any corresponding period. On September 17 the long threatened strike came which checked at once a large tonnage. As early as September 10 there had been a general rush to buy coal and thereafter prices went upward by jumps. The companies nominally were selling at circular

figures—$3·50 for broken, $3·75 for nut, and $4 for stove and chestnut—but they refused new business and dealt only with their regular customers. Stove coal sold as high as $6·50 and over at retail in New York City. But the higher prices brought forward coal enough for all pressing needs until production was resumed late in October through the calling off of the strike. But winter was at hand and finding a demand for all of the coal that the mines could supply, the mining companies raised the prices for hard coal at all ports of shipment 50c. above the circular prices of July 1. Production during November was active, but the demand was strong, and the output of 4,971,576 tons did not begin to satisfy consumers. The December production of 4,800,000 tons but slightly decreased the demand, prices continued firm, and occasional spot cargoes even commanded a premium.

The average selling prices of prepared sizes of free-burning white-ash coal f. o. b. New York harbor ports in the respective years 1899 and 1900 compare as follows:

Months.	Broken.		Egg.		Stove.		Chestnut.	
	1899.	1900.	1899.	1900.	1899.	1900.	1899.	1900.
January–June	$3·13	$3·14	$3·27	$3·37	$3·59	$3·72	$3·53	$3·73
July–December	3·22	3·33	3·49	3·57	3·92	4·07	3·93	4·08

The total production for 1900 was 45,180,641 tons, which fell below the previous year's record-breaking figures of 47,665,203 tons but, notwithstanding the strike, the year ended with more favorable returns for the mining and transportation companies than for many years previous.

The Atlantic Seaboard Bituminous Coal Trade in 1900.

It is now well recognized, not only at home but in Europe, that the bituminous coal mined in certain districts of the United States meets in a high degree all the demands of the consumer. These districts lie in central Pennsylvania, the Cumberland region in Maryland, and along the lines of the Chesapeake & Ohio Railroad in Virginia, and the Norfolk and Western in Virginia and West Virginia. Some of this coal is coking and well fitted for gas manufacture, most of it is well adapted for ordinary steam production, and some of it is the best coal that can be had for naval use. A noteworthy feature of the year 1900 has been the increase in shipments of bituminous coal to European countries, and there is every indication that this demand from abroad will continue to grow.

An event of great importance in the bituminous coal industry was the acquisition by the Pennsylvania Railroad Co., in 1899, of controlling interests in the Baltimore & Ohio, the Chesapeake & Ohio, and the Norfolk & Western Railroads. This move, which brought the four great coal-carrying roads under one control, was quickly followed by the announcement of higher freight rates from the mines to tidewater, and the assignment of a definite sphere of operation to each of the four roads in the distribution of the various coals. It was also made clear that strong efforts were to be made to secure foreign business by securing agents at foreign ports and by providing adequate shipping facilities for deep-water vessels on this side. Early in 1900, under the stress of a short supply and great indus-

trial demand abroad, inquiries and orders for coal began to come from European firms, particularly from points on the Mediterranean. This demand continued throughout the spring and summer, with considerable shipments of coal to Sweden, Spain, Germany and Austria. With the coming of autumn the call for coal abroad abated and it continued to decline until the end of the year.

At home in January the bituminous coal trade opened with a strong demand by buyers. Coal sold as high as $3·75 f. o. b. New York harbor, and at Boston as high as $5. Production during the month was heavy, and the seaboard consuming ports took all the coal they could get. In February and March the mines were still active. The demand for coal in Eastern manufacturing centers continued, but the movement of coal was large and prices declined. Coastwise freights from Philadelphia were high and the railroads announced an increase of 35c. in freight rates. In April, came an abatement of demand, followed in May by a further decline with weakening prices. June and July were dull, but early in August business began to pick up. About 60% of the men who, to the number of 6,000, had gone on strike at the Georges Creek fields in April, returned to work on August 7, and soon the mines were getting out coal as fast as car supply would permit, finding a ready market for all they could produce. Throughout September and October, although the demand for coal was very strong, the railroads showed no desire to help the mines and, either through short car supply or poor transportation, the movement of coal toward customers was tediously slow. The Pennsylvania management for the most part cut the number of cars desired by the Maryland and Pennsylvania mining companies down to from 25 to 50% of the number needed, although it is said that some companies were more favored. November opened with an easier market. Shipments to down-east points were liberal, and along Long Island Sound there was a heavy demand for good coal. During November and December producers found the market growing steadily easier for all but the best grades of coal. The year closed with the better coals in active demand and poorer grades in plentiful supply. In December a number of West Virginia mine owners, who ship over the Chesapeake & Ohio Railroad, organized the Kanawha and New River Coal Co. The announced purpose of the company is to act as a sales agent and to try to secure the proper distribution of cars to the different mines in its territory.

The decision of the Pennsylvania Railroad Co., in all the main lines under its control, to increase by 10c. per ton the freight rates from the mines to tidewater for the year 1901, checked a movement toward lower prices. That the control held by the Pennsylvania Co. has benefited the producer as much as was promised seems doubtful. It certainly has not benefited the public. The company's arbitrary policy, particularly in the matter of car supply, has not met with favor from producers, who have seen possible sales cut off thereby. But it must be said that the ascendancy of the Pennsylvania company has accomplished some good. It has ended the cut-throat policy which so long prevailed, with the result of freight rates unsatisfactory to the railroads and it has abolished the competition of different coals in the same market which caused low prices and unsatisfactory returns to the mine owners, being in some fields fully 50c. above the average for 1899. All things considered the mining companies had on the whole a busy and very prosperous year.

The Manufacture of Water Gas, with Special Reference to European Conditions.

By George Lunge.

Water gas was originally invented in Europe and was there manufactured for a long time before its introduction into the United States. The recent development of the industry to its present state of efficiency, however, has been due mainly to American energy although the object in view was almost exclusively the application of the gas for illuminating purposes and not as a general heating agent. During the time of the development in the United States the practice in Europe retrograded. About the year 1880 American methods were introduced into Europe, and at first were simply copied. Later they were modified to suit the altered conditions. In Europe the application of water gas for illuminating purposes made very slow progress for a time, and although, recently, a much quicker pace has been adopted in this respect, yet the development is still very much behind American progress. On the other hand, European practice has been developed along lines that may ultimately be of even greater importance, *viz.*, the use of water gas for heating purposes. The progress in this case however has also been very gradual, as until quite recently the high cost of water gas prohibited its use for general heating purposes, and restricted it to special cases where extraordinarily high temperatures were required—a state of affairs that is now being changed.

The history of the earlier stages of water gas, and its development in America has been fully described elsewhere, especially in the report of the Committee on "Water Gas," William H. Wahl, Chairman, that was appointed in 1886 by the judges of the "Novelties" Exhibition of the Franklin Institute, and in a prize essay that was published by M. Geitel, entitled *"Das Wassergas und seine Verwendung in der Technik"* (2nd edition, 1899). The report of the committee gives, in a succinct manner, the reasons for the presentation of a grand medal of honor to Thaddeus S. C. Lowe, and after enumerating the various elements of the process, as it then stood, concludes with the following statement: "Each of these elements, whether separately or united had been previously suggested or applied in part. For example the principle of internal combustion, by George Lowe in 1831; the mode of admitting air and steam to the generator alternately, by Fages in 1860; the heat-economizing features, by Cruikshanks in 1839, by the Kirkham Brothers in 1852, and in an eminent degree by the Siemens Brothers from 1856 to 1863, but the combination of the three in a practicable form for the purpose of producing a gaseous product, suitable either for fuel or illumination does not appear to have been made or suggested prior to the first publication of what has since come to be known as the 'Lowe process.'"

To this should be added the facts that Lowe's patent was granted September 21, 1875 (United States Patent No. 167,847), and that the first plant under this system was put in operation at Phœnixville, Pa., in 1874 and has been used continuously to the present time.

The later history of water gas in America is undoubtedly well known to the

readers of THE MINERAL INDUSTRY, although they may be less familiar with the European development, which is described further on.

A brief description of the principle of producing water gas is as follows: When steam is passed over incandescent carbon (preferably in the shape of coke or anthracite) the subjoined reaction takes place:

$$C+H_2O=CO+H_2;$$

that is to say, equal volumes of carbon monoxide and hydrogen are formed, both of which are inflammable gases, their mixture possessing the caloric value of 2,800 metric heat units per cu. m., an amount one-half the heat value of good coal gas that has been made by distilling bituminous coal in retorts. The heat produced by gram-molecules is, for $CO+H_2+O_2=CO_2+H_2O=68{\cdot}4+57{\cdot}6=126$ heat units, whereas the direct combustion of carbon, $C+O_2=CO_2$, produces only 97 heat units. It stands to reason that the introduction of an incombustible substance like water cannot be the source of fresh energy, and the apparent gain of energy represented by the figure: 126—97=29 heat units must be explained by its introduction from an extraneous source. This is found in the heat that accumulates in the incandescent fuel. The reaction: $C+H_2O=CO+H_2$ is endothermic; *i.e.*, it takes place with expenditure of heat. The splitting up of H_2O requires an expenditure of 57·6 heat units of which only 28·6 are supplied by the reaction $C+O=CO$, so that a difference of 29 heat units has to be made good. This amount is exactly equal to the apparent gain in the use of carbon for making water gas instead of burning it directly to CO_2, a gain that is thus explained as derived from an extraneous source.

In the long run these 29 heat units must be supplied apart from the incandescent fuel, the temperature of which constantly sinks and soon falls below the point where the reaction $C+H_2O=CO+H_2$ is prevailing, (assumed to be above 1,000°C.). Below this temperature another reaction comes into play, *viz.*, $C+2H_2O=CO_2+2H_2$ which produces a gas composed of one-third inert carbon dioxide and two-thirds combustible hydrogen. As this second reaction is also of endothermic character the temperature soon falls to a point where the process is at a complete standstill. But this condition may be prevented by the introduction of a fresh source of heat either from extraneous heating of the generators (a system used by the first inventors but long since abandoned, as it was too costly), or from the combustion of carbon within the generator.

The latter method may be carried out in two ways. The first of these is as follows: A certain quantity of atmospheric air is passed with the steam into the generator in order to produce, by the reaction C+O, a sufficient quantity of heat to supply the 29 heat units above mentioned. This result is attained as nearly as possible by regulating the proportions in such manner that it may be expressed by the equation: $2C+H_2O+O=2CO+H_2$. As the atmospheric oxygen is accompanied by four times its volume of nitrogen, the resulting gas must by theory, contain 40% N, 40% CO and 20% H. In practice this gaseous mixture contains more nitrogen, less hydrogen, less carbon monoxide, and at least 5% CO_2, and it has been extensively applied, especially since Dowson worked out its use for gas engines in 1886, a result that has led to the name of "Dowson

gas," although it was known long before Dowson—and Schilling, Bunte, Wilson, Loomis and other inventors are now producing it equally well by other types of gas producers. The great advantage of this gas is its cheapness. It is produced continuously by a process almost as simple as that used in the manufacture of ordinary producer gas, which consists of carbon monoxide with at least a double volume of nitrogen. This is often called "Siemens gas" to distinguish it clearly from other heating gases. The great dilution of Dowson gas with nitrogen and its low heating power, which is about 1,200 or 1,300 heat units per cu. m., places it beyond favorable comparison with real water gas. The idea has been suggested to produce a gas entirely combustible by a process of this kind, using pure oxygen instead of atmospheric air and thus avoiding the dilution with nitrogen; the use of pure oxygen for such a purpose, however, is at present beyond the range of technical possibilities.

If real water gas is to be made by internal combustion, the operation must be divided into two distinct phases or stages. Beginning with a stock of incandescent coal in a generator 2 or 3 m. in height and at a temperature of about 1,200°C., steam, preferably in the superheated state, is introduced and real water gas is thus formed according to the reaction

$$C+H_2O=CO+H_2.$$

Soon, however, the temperature sinks, and carbon dioxide CO_2 is produced in the gas by the secondary reaction

$$C+2H_2O=CO_2+2H_2.$$

Before the carbon dioxide begins to prevail, the steam must be shut off, the temperature being then below 1,000°C. This whole period of "steaming" lasts 4 or 5 minutes and the gas produced during this period is called "blue gas." Its composition approximates theoretical water gas; usually it contains by volume 48 to 50% H, 40 to 45% CO, 4 to 5% CO_2, 4 or 5% N. The heating value of blue gas is about 2,600 heat units per cu. m., and it may be used either as a fuel or for illuminating purposes; in the latter case, however, it must first be made luminous by carburation, or else be used for the incandescence of platinum, magnesia, thorium oxide or other suitable agents.

Immediately after the steam is shut off, the "blowing up" or second stage begins; air is blown into the generator, whereby carbon is burnt and the temperature at once rises. When it has reached the required degree, the air-blast is shut off, and the generator is ready for another "steaming." Until quite recently the blowing-up was carried on exactly as in the manufacture of ordinary producer gas (Siemens gas), so that the carbon was burnt to monoxide only, thereby generating 29 heat units instead of 97 heat units which were set free for each atom of carbon; but this was considered unavoidable, as the great bulk of fuel contained in the generator must necessarily reduce any carbon dioxide formed to carbon monoxide, and probably at such high temperatures that from the first carbon monoxide only is formed. This drawback has been overcome by the Dellwik-Fleischer process described later. Formerly in every case, and even now wherever that process is not employed, the blowing gas carries away a great por-

tion of the heat-value of the fuel which is sometimes entirely wasted and is at best but partially utilized for "fixing" naphtha vapors, raising steam or other minor applications The blowing-up stage lasts generally about ten minutes.

The development of water gas in Europe is briefly summarized as follows: Before Lowe's patent had been issued and while his system was still on its trial, many other inventors were occupied in this field. In America the processes of J. M. Sanders (1858), of Gwynne-Harris (1863), of Tessié du Motay (1873) and of Wilkinson (1876), represent this industry; in Europe, since 1860, those of Schäffer and Walker (1861), of Pütsch, Westphal and Ziurek (1867), of Ruck (1871), of Livesey and Kidd (1878). The introduction of the Lowe process into Germany (German patent of Thaddeus S. C. Lowe and G. S. Dwight, No. 3,515, of 1878), formed a new era and the full development of the principle was attained by the passage of the gas, produced during the "blowing-up" stage, through a "superheater," where it was burned by air that was added, and by the subsequent use of the products of combustion for raising steam in a tubular boiler. The superheater is used to "fix" the naphtha vapors that are required to impart luminosity to the blue water gas.

The apparatus of M. H. Strong, which differs from that of Lowe and Dwight merely in the details of the various stages, was patented in Germany even before that of Lowe (No. 3,178), although it has not attained prominence any more than the apparatus of H. C. Bull (German Patent No. 12,576), which was followed soon after in 1880 by a patent of Dwight and Quaglio (No. 13,490). The German partner, Quaglio, did his best to promote the introduction of water gas by means of pamphlets, lectures and the like, and although he did not have any prominent success in the direction in which he was personally interested, it is undoubtedly due to him that growing interest was shown for water gas in Germany.

A decisive step toward the independent development of this industry in Germany was the taking up of the Lowe system by the firm of Schultz, Knaudt & Co., in Essen on the Ruhr, which employed it in their iron-rolling mills for welding corrugated plates. This operation requires an extraordinarily strong heat, and cannot be practically carried out by any other agent than water gas. One of the partners, Mr. A. Knaudt, constructed for this purpose special water-cooled tuyeres (German Patents No. 17,810 and 20,174, in 1881 and 1882), and at the same time by Patent No. 18,719, he applied the principle of water-cooling for the protection of the conical bottom of the generator, where the greatest heat exists, and where the brick work is most exposed to destruction. Knaudt's patents were acquired by the "Europäische Wassergas-Gesellschaft," of Dortmund, and Mr. E. Blass, their chief engineer, perfected the process, at the experimental station at Essen. One of his principal improvements consists of the automatic movement of the valves, which is required to change from steaming to blowing-up and *vice versa* (German Patent No. 35,943, of 1895). In making the water gas the following operations have to be performed every few minutes: (1) During the blowing up the outlet valve into the chimney must be opened, and the steam must be shut off from the generator. (2) When the steaming begins, the outlet valve for the blue gas into the scrubber must be opened, the

connection into the chimney and the air-blast valve must be closed, and the steam valve connected with the generator must be opened. (3) During the charging of fresh fuel, both the steam valve and air valve must remain shut, while the charging valve must be opened. All these movements must take place in a definite order, and any oversight in this respect will cause trouble or even explosions. It is consequently important to simplify the course of operations by an arrangement of the following description. The valves are all connected by means of toothed-gear, rods, etc., with a wheel, by the turning of which they are opened and shut exactly in the required order. To set all the valves in the proper position for blowing-up, the wheel is turned one way; for gas-making it is reversed. The attendant simply turns the wheel at the proper time, whereby two valves are opened and two are shut in the order required by the operation.

A later patent of the Wassergas-Gesellschaft (No. 36,431, 1895) tries to solve the question of using bituminous coal in the generator, in place of anthracite or coke. For this purpose the blow-up gas is burned in a recuperator, and the heat is utilized for superheating steam, part of which serves for gas-making in the usual way, while the other part is made to pass through fresh coal, and to volatilize the bituminous substances. The gases and vapors thus produced are used either for ordinary illumination or for mixture with the steam in making the blue gas, and they act similarly to fixed carbon for this purpose. The principle of this invention seems to be sound, but it has not found any practical application up to the present time. The same corporation describes an arrangement for generating the steam for the production of water gas (German Patent No. 36,665, 1895).

About 1885 the "German type" of water gas apparatus had been fully developed, as shown in Figs. 1 and 2. These generators were erected at Essen, Hoerde, Wittkowitz and other places, and were specially intended for fuel of inferior quality. Fuel of this kind must be used in a somewhat high column to present a sufficiently long distance for the passage of the steam, an arrangement that requires a blast of correspondingly greater pressure. It has been found most suitable to introduce the steam at the top and to make it pass downward through the fuel; it thereby travels in more regular channels and meets the fuel on its way, in an increasingly hotter state, which renders its decomposition more complete. The blue gas is removed through the same place that the air-blast enters. If the air valve is not perfectly tight, air might find its way into the scrubber and the gas-holder and, together with the gas, might cause a bad explosion. This contingency is avoided by a specially constructed water-cooled slide *S*, as the temperature is very high where the valve is exposed; a throttle valve *d*, below affords an additional security. If the slide faces are not perfectly tight a mixture of air and gas will be formed on reversing the currents, which explodes out of the openings, *a*, without damage. The removal of the cinders is facilitated by the cooling-ring, *K*, from which they can be easily detached. This producer is intended to work with fuel that contains a large proportion of ashes, a cone of fuel being formed below the cooling-ring which leaves a free annular space, *A*, into which the blast enters, and where it

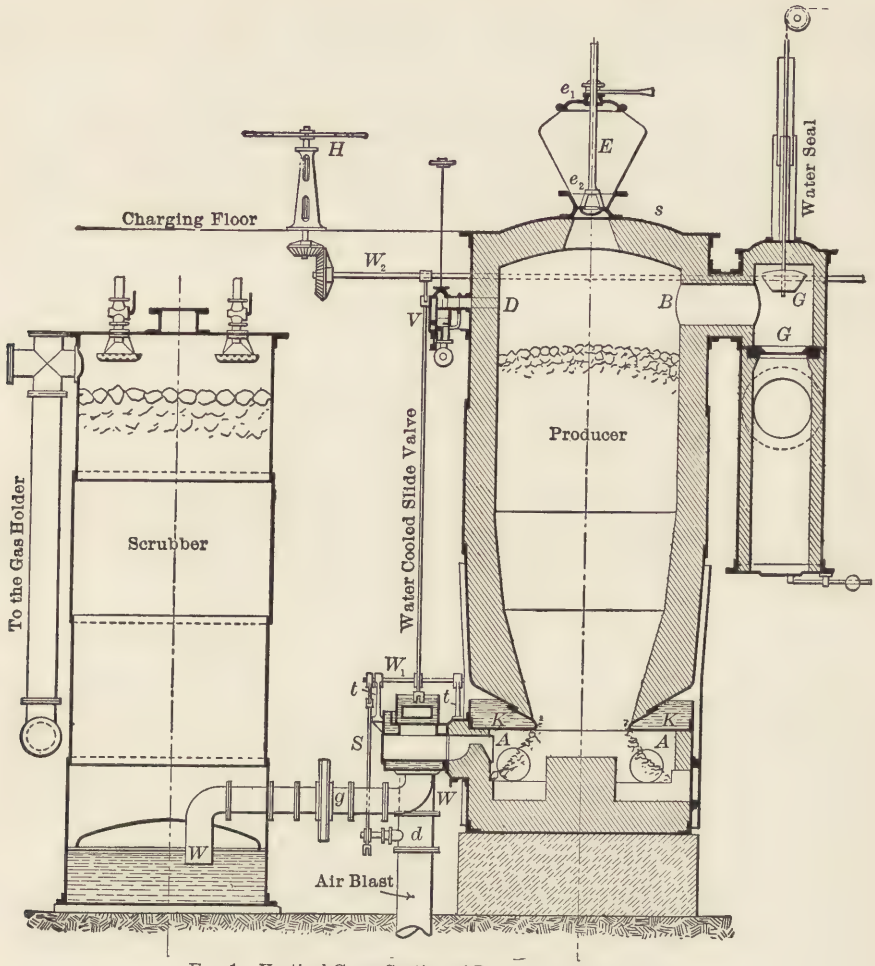


FIG. 1.—Vertical Cross-Section of Producer and Scrubber.

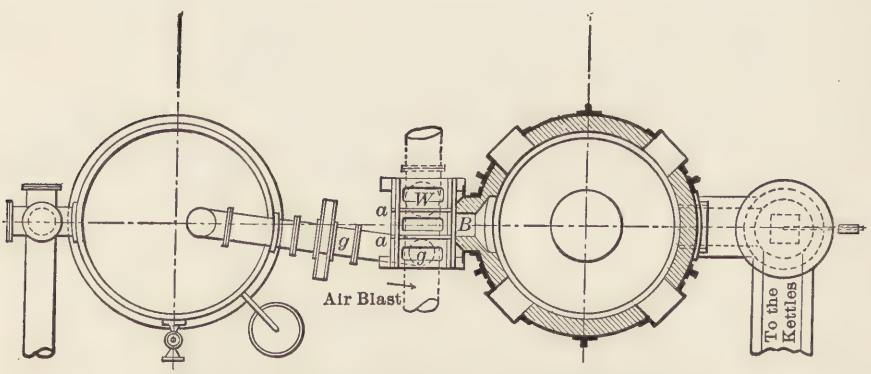


FIG. 2.—Horizontal Cross-Section of Producer and Scrubber.

WATER GAS PRODUCER, GERMAN TYPE.

is very equally distributed. *B* is the outlet and *C* the valve for the Siemens gas made during the blowing-up, *D* the steam tuyere, *V* the slide-valve for steam, *E* the charging-hopper with the slides E^1 and the cover E^2. The arrangement of standards *t*, shafts, W^1 and W^2, hand-wheel *H*, etc., refer to the automatic reversal of the valves, when changing from blowing-up to steaming and *vice versa*, as previously mentioned. The pressures in the generator and scrubber must be regulated exactly. In the generator during the blowing-up it is 400 mm. at bottom, 180 mm. at top, in the scrubber 120 mm.; during the steaming in the generator the pressure at the top is 700 mm., at the bottom 400 mm., and in the scrubber 250 mm.

In 1890 E. Blass made a number of statements concerning the cost of working with this apparatus, from which the following is quoted: The consumption of fuel per cu. m. of water gas is 1 kg., or if the blow-up gas (Siemens gas) is rationally employed (which is just the difficulty) 0·5 kg.

Ferd. Fisher has published a detailed examination of the Essen water gas plant, of which the following is a short abstract. This plant at his visit produced in 5·75 hours 3,699 cu. m. water gas from 3,256 kg. coke, or 1·13 cu. m. per kg. coke, the latter containing 84·4% C, 0·5% H, 2·1% O and N, 10·6% ashes, 2·0% moisture. The gases were composed as follows:

	Blow-up Gas.				Blue Gas.			
	After 1,	6,	10 minutes.		After 1,	2,	3 minutes.	Average.
CO_2	7·04	4·03	1·60	CO_2	1·8	3·0	5·6	3·3
CO	23·68	28·44	32·21	CO	45·2	44·5	40·9	44·0
CH_4	0·44	0·39	0·18	CH_4	1·1	0·4	0·2	0·4
H_2	2·95	2·20	2·11	H_2	44·8	48·9	51·4	48·6
N_2	65·89	64·94	63·90	N_2	7·1	3·1	1·9	3·7

The temperature of the blow-up gas rose to 505°C.; the average heat value was 950 heat units, and it contained 0·718 kg. carbon per cu. m.

Average heat value of the blue gas was 2,970 heat units, and it contained 0·291 kg. carbon per cu. m. The remaining 0·557 kg. C furnished 3·13 cu. m. Siemens gas. Hence of the 7,000 heat units of the coke, 3,000 were recovered in the water gas (43%) and 2,970 in the Siemens gas (42%); the cooling water (7,620 liters per hour) accounts for 800 heat units per kg. coke; the 0·45 kg. steam, required for 1·133 cu. m. water gas, represent 290 heat units so that there is a loss of 550 heat units by radiation.

Most of the water is required for the cooling-ring *K*, (Fig. 1). This cooling process also causes the loss of a good deal of unburned coke which is withdrawn with the cinders, and it involves as well the stoppage of the generator during the removal of the cinders, which means that the evolution of Siemens gas completely ceases during this time. These drawbacks apparently more than counterbalance the advantages of the cooling-ring, and have led to its frequent abandonment. The cooling of the slide valves however has been retained; it is very useful.

Mr. I. von Langer, the engineer in charge of the German apparatus at Wittkowitz, introduced certain modifications by a German patent (No. 57,412, in 1890). He afterward associated himself with S. Fox for developing the

water gas industry in England by means of his inventions; the history of this venture is probably known to most readers of THE MINERAL INDUSTRY.

The attempt of Mond and K. Langer (German Patent No. 51,572, 1889) to remove the carbon monoxide and the hydrocarbons from water gas by means of metallic nickel or cobalt at a temperature of 350 or 400°C., in order to produce almost pure hydrogen, is very interesting, but hardly practicable. Nor has success been obtained by the patent of F. Krupp (German Patent No. 67,827, of 1892) which aims to prevent the formation of carbon monoxide in steaming by soaking the fuel with alkaline carbonates; the carbon dioxide formed in this case was to be removed later by a suitable absorbent, which would leave pure hydrogen behind.

The well-known apparatus of Humphreys and Glasgow, which during the last few years has been erected in many places in Europe, is of American origin. It embraces two generators, two carburetters and two superheaters.

This apparatus, as well as those of Messrs. Merrifield & Pearson ("Economical Process") and of Samuel Cutler & Sons are all of an improved "Lowe" type.

Much attention has been awakened on the Continent by the labors of Mr. H. Strache, who first attracted attention by the invention of a method (German Patent No. 72,816, 1893) which overcame the objection to the use of water gas for the Welsbach light. When water gas was first used for this light, a brown coating of ferric oxide was formed on the incandescent mantles. This coating was due to the formation and decomposition of iron carbonyl, which can be removed by passing the gas through red-hot tubes, or by washing it with strong sulphuric acid. Later Mr. Strache directed his energies to the use of bituminous coal or other cheap fuel in place of anthracite for the manufacture of water gas. His system, which does not differ in principle from that of E. Blass, and rests equally on a previous treatment of the fuel by superheated steam, is given in the German Patent No. 90,747 (1895). It has been carried out on a comparatively small scale in Austria, but has not hitherto found any further extension. It seems that in its present shape it does not work unless the coal is mixed with coke. It remains to be seen whether in this or in some other way the task of employing cheap fuel for water gas making will be ultimately accomplished. Then and then only water gas will make its way as a general fuel, instead of being limited to special, although very important purposes.

Strache and Jahoda have published* the results of experiments made with the former apparatus, and a long list of calculations based thereon, which are not possible to present in condensed form. The authors lay the greatest stress on burning the gas that is formed during the blowing, and storing up of the heat in a recuperator. The statement made by the Internationale Wassergas-Gesellschaft, Strache's patent,† according to which the Strache system produces from 2·5 to 3 cu. m. of water gas from 1 kg. C, is so manifestly wrong that it throws a doubt upon the correctness of the other statements and calculations in question. A simple calculation will make this clear. One kg. C on direct combustion in the calorimeter produces 8,080 heat units, and beyond this theoretical maximum

* *Journal für Gasbeleuchtung und Wasserversorgung*, 1900, pp 355, 572, 574, 694, 709-957.

† *Technische Rundschau*, No. 51, 1899.

it is not possible to go even when the carbon is used for the manufacture of water gas. In fact in the latter case a deduction must be made of the heat required for raising the steam from 1·5 kg. of water (1·5×954 heat units), leaving only 7,126 heat units. Since each cu. m. of water gas yields 2,600 heat units, 3 cu. m. (the quantity alleged to be obtained by Strache's process from 1 kg. C) represent 7,800 heat units, which is much more than 7,126; furthermore, no allowance is made of the heat lost by radiation from the apparatus, and that carried away by the gases. Whether the generation of steam is included or not, a production of 3 cu. m. water gas per kg. C is quite impossible, and any representations to that effect render the basis of the calculation entirely fallacious.

The latest development of water gas was brought about in the first instance by a Swedish engineer, Carl Dellwik, and was considerably promoted by the scientific investigations of Dr. Emil Fleischer, of Dresden. In order to explain the principle and the advantages of this process, the following notes are appended from the paper read by Mr. Dellwik before the Iron and Steel Institute, in May, 1900, which are supplemented from other sources. I should state that much of the following description has been confirmed by my own observation.

The process of water gas manufacture consists in the alternate heating to incandescence of a bed of fuel by means of an air blast, and the subsequent decomposition of steam in contact with the fuel thus heated, until the decrease in temperature necessitates a new period of heating. In all processes hitherto in use both of these periods (of water gas making and of blowing) have yielded combustible products, each containing a portion of the heating value of the fuel. The generators may have varied in form and may have used an air blast, a forced draft or a down draft for the periods of heating or blowing, but the chemical reaction has always been constant, *viz.*, a combustion to carbon monoxide, so that the gas leaving the bed of fuel in the generator consisted principally of carbon monoxide and nitrogen. The most important problem in the construction of a large water gas plant on this principle has therefore been to find suitable employment for the producer gas, which contained the greater portion of the heat of the fuel. The difficulty of doing this, especially the difficulty of utilizing it in the same proportion in which it is generated, has, in fact, formed one of the most serious obstacles against the introduction of water gas. Various devices have been used to increase the yield of the more valuable product, water gas, as for example the preheating of the air, or steam, or both, for the water gas generator. These arrangements, however, have proved more or less ineffective, besides complicating the apparatus, and the ordinary practice in the production of "blue" water gas has therefore been simply to use the producer gas to generate the steam for the water gas manufacture. But even this has not always been done, and the insufficient utilization of the fuel has effectually prevented the general introduction of water gas.

As the chemical reaction in the generation of water gas is always the same, it is evident that the condition for an economical production of water gas is to effect the greatest possible utilization during the blows, of the heat contained in the fuel, and to accomplish this a complete combustion in the generator is produced. Practical results have shown that it is possible to establish by very

simple means such conditions in the generator that during the blows a practically complete combustion to carbon dioxide is obtained within the bed of fuel to be heated, while at the same time conditions favorable to the water gas making are maintained. The radical difference then, between the "old" processes and the method originated by Dellwik, is, that in the former the gas, while leaving the generator during the "blow," contains principally carbon monoxide together with the inevitable nitrogen, while in the latter it consists principally of carbon dioxide and nitrogen.

Taking into consideration this difference in principle, a brief study of the effect of these different methods is outlined below. The chemical reaction in the formation of water gas proves that 18 lb. of steam, which consists of 2 lb. H and 16 lb. O requires for the decomposition $2\times28{,}780=57{,}560$ heat units. The 16 lb. O combines with 12 lb. C to form 28 lb. CO, which in mixture with the 2 lb. H forms 30 lb. equal to 753·4 cu. ft. of water gas. The heat developed by the formation of the CO is $12\times2{,}400=28{,}000$ heat units, which leaves a balance of $(56{,}560-28{,}800)=28{,}760$ heat units, that must be replaced by combustion of carbon during the blows. Assuming, as is approximately the case in practice, that the blow gas leaves the generator at a temperature of 700°C., we find:

	Old Methods.	Dellwik Method.
1 lb. of C requires for combustion	To CO : $\frac{16}{12}$ lb. O.	To CO_2 : $\frac{32}{12}$ lb. O.
This O is accompanied by	4·32 lb. N.	8·64 lb. N.
The products of combustion carry away at 700°C	1,136 h. u.	2,092 h. u.
The heat of combustion of 1 lb. C is	2,400 h. u.	8,080 h. u.
Balance available for heating fuel	(2,400—1,136)=1,264 h. u.	(8,080—2,092)=5,988 h. u.
To fill the balance of 28,760 h. u. required for making 30 lb. water gas, must therefore be burned	$\frac{28{,}760}{1{,}264}$=22·75 lb. C.	$\frac{28{,}760}{5{,}988}$=4·83 lb. C.
Apart from loss by radiation, etc., there are required for making 30 lb. (753 cu. ft.) of water gas	12+22·75 =34·75 } lb. C.	12+4·83 =16·83 } lb. C.
Or: per 1 lb. C is produced	21·7 cu. ft. water gas.	44·7 cu. ft. water gas.
As water gas of theoretical composition contains 167 h. u. per cu. ft., there are utilized in water gas from 1 lb. C	3,627 h. u.	7,465 h. u.
Which is equal to	48% of the total heat of C.	92·5% of the total heat of C.

Of course losses occur in the practical working, by radiation, by the formation of carbon dioxide, etc., as in all other processes. In the Siemens process, the practical efficiency may be estimated at from 60 to 72%. In the old water gas processes the quantity of gas formed during the blows is amply sufficient to raise the steam needed for the process; in the new process the escaping heat is only sufficient to preheat the feed water for the boiler. We must therefore add 12 to 15% of fuel for the steam which reduces the theoretical quantity of gas obtained from 12 lb. of carbon, to 656 cu. ft., and limits the possible utilization of the heating value of the fuel to about 80%.

The practical working of the old water gas process is well known. In generators of a small size a yield of about 12·5 cu. ft. per pound of ordinary coke may be counted on, while larger generators under favorable conditions produce about 16 cu. ft. The water gas differs somewhat from that theoretically calculated, and its calorific power is about 158 thermal units per cu. ft. With coke of 7,000 heat units per lb., the utilization of the heat by these processes is from 28 to 36%.

It is shown later in this article how closely the Dellwik-Fleischer process in practice approaches the theoretical calculation.

A few years ago, when the preliminary experiments had been completed, a few of the leading authorities of the gas industry were invited to examine the results obtained. The first to accept the invitation was Prof. Vivian B. Lewes, of London, who summed up the result of his test as follows: One thousand cubic feet of water gas, containing 15 lb. C is obtained by a total expenditure of 29 lb. C, so that more than 51% of the carbon is obtained in the gaseous form, while the remaining 49% is expended to produce the hydrogen of the water gas. The coke used in the experiments contained 87·56% C, or 1,961·3 lb. per ton, which equals 15,876,307 metric thermal units, and this amount yielded 77,241 cu. ft. of water gas. The sp. gr., as taken by the Lux balance, was 0·5365, and the gross calorific value, as determined by Junker's calorimeter was 4,089 thermal units. Hence the calorific value of water gas from a ton of coke was 13,033,059·8 thermal units, or more than 82% of the heating value of the coke used in both generator and boiler. In this calculation 20% has been deducted for raising the required steam, but in a large installation this amount could be reduced, with a consequent increase in the percentage of the total heating value of the coke obtained in the gas. The labor needed will be less than in the ordinary process, as less fuel has to be handled.

Tests made by Prof. Bunte, of Karlsruhe, Dr. Leybold, of Hamburg, and myself, have given similar results.

The most trustworthy figures for continuous work have been obtained from an installation at the City Gasworks at Königsberg, in Prussia, where an average yield of 38·44 to 39·74 cu. ft. of water gas was obtained per pound of carbon contained in the coke charged into the generator. This corresponds with a utilization of 75·2 to 77·7% of the heat value of the fuel. At another gas plant the test showed a yield of 41·6 cu. ft. per pound of carbon, or an efficiency of 81·3%.

The method of operating the Dellwik generators illustrates the departure from the old systems. In the latter, the duration of the blow is from 10 to 15 minutes, and the water gas is made during the following 4 or 5 minutes, while in the Dellwik generators the blow lasts only 1·5 to 2 minutes, and the water gas is subsequently made for 8 to 12 minutes. Another feature of the new method is that during the blow the combustion continues throughout the entire depth of the fuel, and the whole bed is thus raised to a uniformly high temperature, which enables the period of water gas production to be considerably lengthened, without any deterioration in the quality of the water gas. Fig. 3 shows the appearance of a generator. The surrounding sheet-iron shell is lined with fire brick, and on a level with the clinkering doors is a grate for the support of the fuel; below this are ash doors for the removal of the ashes. The air enters through the blast valve, and the blow-gas leaves the generator through the central stack-valve, which also serves as a charging opening for the fuel. There are two water gas outlets, one at the top of the generator and one below the grate; both are connected with a three-way valve through which the gas passes on its way to the scrubber. The gas pipe is water sealed in the bottom of the scrubber, where the

gas is cooled, and the dust is washed out of it by the water flowing over the coke therein contained. From the scrubber the gas passes to a small gas-holder, which equalizes the flow of the gas to the place of consumption. There is also a steam pipe which leads to the bottom and to the top of the generator. Figs. 4 and 5 show a section and side elevation of the Dellwik-Fleischer generator.*

The method of working is as follows: A fire having been built on the grate, and the generator filled to the proper level with coke, the blast valve is opened and the fire raised to a high state of incandescence in a few minutes. One of the gas outlets—the upper one, for instance—is then opened, the blast and stack

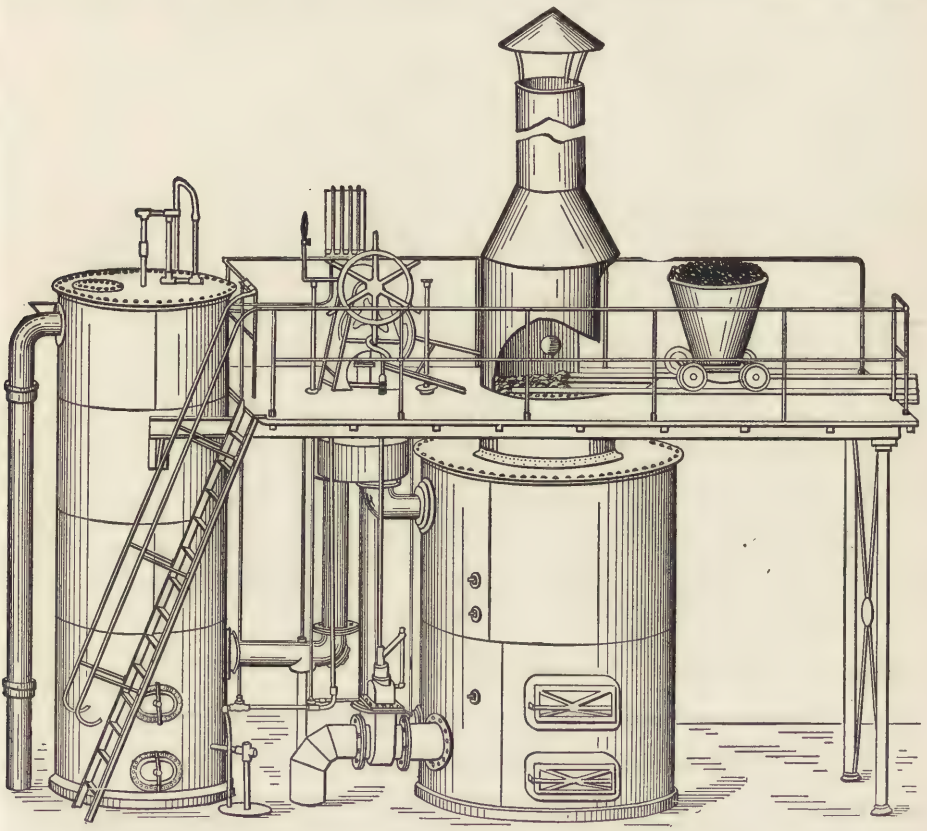


FIG. 3.—THE DELLWIK-FLEISCHER WATER-GAS PRODUCER.

valves being simultaneously closed by means of the gearing on the working stage. Steam is admitted to the bottom of the generator, and is decomposed in its passage through the bed of incandescent coke, resulting in the formation of water gas. A set of water-gauges and a test flame indicate the condition of the apparatus and the quality of the gas. When the temperature of the fuel has sunk below the point where carbon dioxide begins to form in a large proportion, the steam is shut off and the stack valve opened, the gas valve being simultaneously closed. The blast valve is then opened for another blow of 1·5

* *Moniteur Scientifique*, May, 1900.

or 2 minutes. For the next period of gas-making the lower gas-outlet is opened and steam admitted above the fuel. By thus reversing the direction of the gas making, the temperature of the fuel is equalized, which diminishes the wear on the brick lining at any one point. The greater part of the coke being consumed by the action of the steam, the incombustible portion is disintegrated to a large extent and falls through the grate as ash; the clinkers that remain on the grate are brittle and easily removed.

From the results already quoted it is evident that this process easily attains an efficiency rather higher than that usual in the Siemens processes, and twice as high as that of the older water gas processes. It is unnecessary to make any

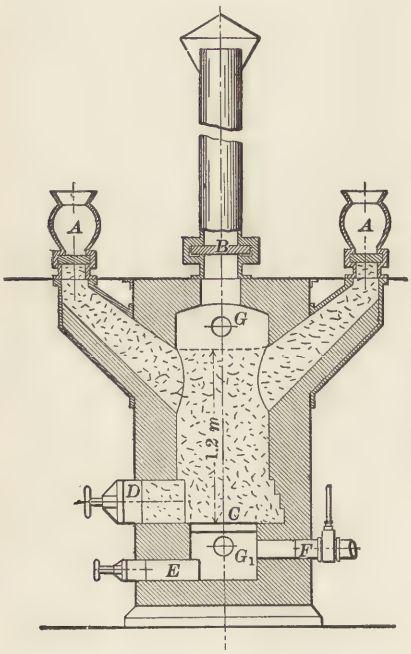


FIG. 4.—Cross Section.

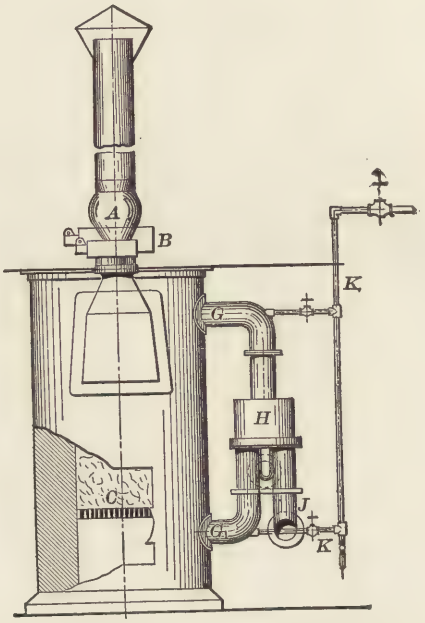


FIG. 5.—Side Elevation and Part Section.

THE DELLWIK-FLEISCHER WATER-GAS PRODUCER.

A, Charging Hopper. *B*, Chimney Damper. *C*, Grate. *D*, Space for the removal of clinkers. *E*, Space for the removal of ashes. *F*, Air Blast. *G*, Upper exit for the water gas. *G*, Lower exit for the water gas. *H*, Register. *J*, Pipe to convey the water gas to the scrubber. *K*, Steam Pipe.

comparison with the latter as to price, but in regard to the former, the thermal efficiency is so nearly equal that the advantage of using one or the other of the two gases must depend almost entirely upon the relative advantages they offer for practical use. The question thus becomes one of quality of the product obtained.

The constituents of water gas are all combustible. Its flame temperature is sufficient to melt a wire of commercial platinum when held in a flame from an ordinary gas burner. Its heating power per volume is two and a half times that of ordinary producer gas, and it can therefore be stored in a holder and conducted to any required distance with the same facility as coal gas. It can be used for

all purposes, being equally efficient for the small glass-blowing lamps for making bulbs for incandescent electric lights, and for melting steel in an open-hearth furnace. It is applicable to all heating stoves and furnaces now so extensively used for coal gas, and for many purposes for which coal gas is too costly. Water gas may be obtained absolutely pure, as the sulphur contained therein is in the form of hydrogen sulphide and may be easily eliminated by passing the gas through iron oxide purifiers; the gas thus formed consists almost entirely of carbon monoxide and hydrogen.

Some years ago tests were made with a view of introducing water gas for open-hearth steel melting at Wittkowitz, in Austria. In a 16-ton furnace 60 cu. m. water gas was used per 100 kg. steel. The time of melting was about the same as with producer gas, but to produce the necessary quantity of water gas, there were required at that time at least 50 kg. coke, or 50% of the weight of steel, which made the use of water gas for this purpose too costly. By the Dellwik-Fleischer process, however, this proportion of coke could be reduced to 28 or 30%. These results have been superseded by a recent installation in a German steel plant near Berlin, which demonstrates in a striking manner the advantages of water gas firing. The charge was melted in two hours with a gas consumption of only 40 cu. m. per 100 kg. steel, which corresponds to a consumption of less than 20% of fuel as compared with the weight of steel produced. In a larger furnace this amount would probably be still further reduced. The saving is by no means confined to a lessened consumption of fuel, but on account of quicker work the capacity of the furnace is more than doubled. The quality of the steel was excellent, and it found a ready market as tool steel, equal in quality to the best crucible steel, though made at a considerably lower cost.

The water gas open-hearth furnace is simpler and cheaper to construct, as the air only is preheated before combustion. The results above given, together with previous experiments on a mixture of water gas and producer gas during the melting, have induced one of the largest steel works in Germany to erect a water gas plant in connection with its open-hearth steel plant. A handsome profit is expected on a safe assumption. One of the advantages counted on is that for very large castings where the charges of more than one furnace are required, several furnaces may be tapped simultaneously.

An argument that is frequently advanced against the use of water gas for large furnaces, is that the flame is too short to fill the furnace properly, and in addition it produces a local heat only which would destroy the brick work in one place, while leaving other portions of the furnace too cold. Experience has shown that this is not the case. When the heat reaches the temperature of the dissociation of steam and carbon dioxide, the zone of combustion extends until the entire furnace becomes equally heated, the flame being visible only as it leaves the furnace; in fact, it has been shown that the only defect of the first furnace was its short construction. It might be expected that the wear and tear of the furnace would be excessive, but this is not the case; at any rate it is not increased in proportion to the increased capacity of the furnace. This effect may be due partly to the cleanliness of water gas, as it is free from dust or ash.

For crucible-steel melting, water gas has not yet been applied except experimentally. These tests, however, have been attended with considerable success;

100 kg. phosphor bronze have been melted in one hour with a consumption of 45 cu. m. water gas, which process is produced by the Dellwik-Fleischer from 20 to 22 kg. coke, while the same quantity of bronze requires two hours and 60 kg. of oven coke for melting in the ordinary way, or three times the quantity of fuel and twice the amount of time.

The widest application of water gas has been made in the welding of iron plates. During the last two years no less than nine water gas plants have been installed for this purpose, and the results have been most satisfactory. The speed of working in the manufacture of boiler flues has averaged 33 to 40 ft. per day, with a consumption of about 800 to 1,000 cu. ft. of gas per foot of weld. In most cases the speed of working has been increased from three to five times above that possible with coke-firing. Of equal importance is the increased comfort of the workmen. The instant the material is heated, the gas supply is cut off and the flame ceases. No work is required to keep the fire in condition by the removal of clinkers. It is not necessary to wait for the heat to develop after fresh fuel has been filled on the fire and, furthermore, the labor of transporting fuel and removal of refuse is abolished. In Great Britain the use of water gas for welding is limited mainly to the manufacture of boiler flues and tubes. On the Continent its application is more varied. One plant in Germany welds masts for warships, and has turned out cylinders in one piece 140 ft. in length and 10 ft. diameter. At a Swedish shop, welded fireplaces for vertical boilers are a specialty, and the entire smiths' forge has been converted to gas firing, with a saving in fuel and time, together with increased cleanliness and comfort, which is greatly appreciated by the workmen.

The conversion of all the fuel into gaseous form at one place and the distribution from this central station of the gas to the different furnaces and places of consumption, is a principle which should recommend itself to all industrial establishments where large quantities of fuel are used, involving labor and waste in transportation. A central gas-producing plant of this character would also supply the cheapest means of generating power. From 30 to 35 cu. ft. of water gas per hour are required for 1 H.P., and as has already been shown, this quantity of gas is produced from less than 1 lb. coke. The efficiency of gas engines of small size is very nearly the same as that of large ones which is not the case with steam engines, and a system of water gas plant and gas engines, therefore allows of a distribution of power far cheaper than is possible with steam engines, and elaborate transmissions with shafts and belts.

The preceding notes have been taken from Mr. Dellwik's paper, whose statements may be considered to be perfectly correct. Turning to the application of the Dellwik-Fleischer process to lighting purposes the gas produced is very suitable, as its composition is identical with that of water gas from other sources, as shown from the following analyses by Prof. Vivian Lewes:

COMPOSITION OF DELLWIK-FLEISCHER WATER GAS.

Components.	%	%	%
H.....	52·43	50·09	52·76
CO.....	38·30	39·95	37·50
CO_2.....	4·73	5·38	4·08
O.....	0·74	1·22	0·46
N.....	3·80	3·36	5·20

The following statements of Mr. H. Dicke, chief engineer of the Dellwik-Fleischer Syndicate, at the International Gas Congress, held during the Exhibition of 1900, at Paris, are trustworthy, and while primarily valid for European conditions they deserve the earnest attention of American gasmen.

Dellwik gas that has been carburetted has already received several applications in gas works. It has been mixed with oil gas in proportion to yield a product approximating the illuminating power and density of ordinary coal gas. With a supplementary water gas plant it is easy to add carburetted water gas to coal gas up to 25% or more by arrangement with local authorities. The ideal conditions are, to have as many retorts distilling coal as will yield enough coke for the production of the water gas. The immediate result of working in this way would be a reduction in the amount of coal distilled, and a consequent appreciable economy—an important consideration in view of the high price of coal. In addition to this, it would become more possible to be independent of foreign coals and to use a cheaper raw material.

On the Continent the system of Humphreys and Glasgow, as well as the Dellwik-Fleischer, occupies a prominent place. The former, which uses oil, cannot be economically worked in France or Germany in consequence of the heavy duties on petroleum. The cost of 100 kg. of Russian petroleum is 15·60 marks ($3·90) in Germany, and in order to make 1 cu. m. of carburetted water gas of 16-candle power 275 g. of petroleum are required, which involves a cost of carburetting amounting to 4·29 pfennig (1·07c.).

In the Dellwik system, benzol is used for carburetting, and of this 80 to 92 g. are used per cu. m. of water gas. The price of benzol is 18 to 20 marks ($4·50 to $5); but taking 25 marks ($6·25) as the outside price, the cost of carburetting amounts to 2·12 pfennig (0·53c.) per cu. m., which corresponds to a reduction of 2·17 pfennig (0·534c.).

Dellwik gas is used for the enrichment of ordinary coal gas as follows: (1) Separate storage of the water gas in a gas holder, and admixture of this pure gas with coal gas before it goes to a large gas holder. The mixture so formed is subsequently carburetted with benzol at the entrance or exit of one of the large holders. (2) Separate storage of the purified water gas (carburetted with benzol) in a holder and admixture with the coal gas before the whole passes to the principal holder. (3) Storage of the water gas in a holder, and its admixture with the coal gas between the hydraulic main and the condensing plant.

In practice the last method is particularly good, for it is economical in the consumption of benzol, as the water gas takes a portion of benzol from the tar during its passage through the condensers. The mixture of coal gas and water gas passes through the entire plant and is brought up to the necessary lighting power by the addition of benzol before it enters or after it leaves the gas holder.

Königsberg was the first city in Germany to use Dellwik gas carburetted with benzol. In 1898 the gas works in this town possessed a gas-holder capacity equal to only 30% of the daily output. The new works under consideration will not be finished before 1902. The manager, Dr. Kluger, on the advice of Prof. Blochmann, of the University of Königsberg, erected a Dellwik-Fleischer

plant, the success of which has exceeded anticipations, and the plant, which was erected for temporary use, is now a permanent part of the works.

Since the installation of water gas in Königsberg, it has been noticed that naphthalene deposits have been much less frequent. The gas is carburetted by the second of the methods mentioned above. The mixture contains from 20 to 25% of water gas, and the lighting power of the mixed gas in an Argand burner of 32 holes is 18 Hefner standard units at 20 mm. pressure. The calorific power of the mixture is about 5,000 calories. No precipitate of iron oxide has appeared on incandescent mantles; and the results with gas motors have been very favorable.

Toward the end of 1900, 14 cities had adopted the Dellwik-Fleischer system for illuminating purposes. Of these 10 are in Germany, one in France, one in England, one in Holland, one in Finland. Ten use water gas, carburetted with benzol and four use pure water gas. Generators to the number of 21 were used for this purpose of an aggregate working capacity per day of from 102,000 to 133,000 cu. m. Twenty-one additional generators, of an aggregate working capacity of from 67,000 to 86,600 cu. m. were operated in 16 iron and steel works, in Germany, England, Sweden and Russia; five at four glass works in Germany and England, producing from 26,000 to 33,000 cu. m. and eight with a capacity of from 25,000 to 32,000 cu. m. at seven miscellaneous works. These data prove the development of a system which promises an enormous extension in the near future.

The Utilization of Blast-Furnace Gases for the Direct Production of Motive Power.

By G. Lunge.

The following account has, to a great extent, been taken from a paper by Prof. Hubert, of Liège, read at the International Congress on Mining and Metallurgy, held in Paris, 1900; but a part, also, is from a pamphlet published by the Society John Cockerill, of Seraing, from publications by Prof. E. Meyer, of Göttingen and by F. Lürmann and from other sources.

The well-known early history of blast-furnace gases needs no discussion. I only would point out an error in Hubert's paper which attributes the first utilization of these gases to a previously unknown M. Fabre-Dufour—a name that points to a Frenchman or Belgian, but which is evidently a confusion with the celebrated Würtemberg engineer, Faber du Faur, whose son, in later years, became an American metallurgist of high standing. Exception must also be taken to Prof. Hubert's statement that "by the middle of this century the exit gases of blast furnaces were commonly employed for heating the blast and for raising the steam for the blowing-engines, hoists, pumps, etc., so that the consumption of fuel had been thereby lowered in the Welsh furnaces to 3 tons of coke per ton of pig-iron." I can testify from personal observation that as late as 1864, when I first visited England, very few of the blast furnaces in Staffordshire and Scotland (districts that I visited at that time) made any use whatever of their waste gases, and I found the same thing on the Tyne a few years after-

ward. It was not until 1870 that it became the common practice to provide all blast furnaces with gas-saving apparatus.

The present world's production of pig iron is about 40,000,000 tons per annum, and the quantity of coal consumed for this purpose, mostly in the shape of coke, is at least 50,000,000 tons. The coal for this purpose must be of a suitable quality, and leaving the remote future entirely out of consideration it does not exist in even comparatively inexhaustible supplies, a condition of affairs that is still further intensified by the tendency to a further expansion in the manufacture of iron. Anything that leads to a material diminution of the immense quantity of coal consumed in this industry must therefore receive the greatest attention, not merely from the ironmaker himself, but from the world in general.

Theoretically 1 kg. iron requires for its reduction from the state of ferric oxide and subsequent fusion, 2,300 metric heat units, which equals 0·29 kg. C, or 0·33 kg. of good coke. In practice the actual consumption of coke is very much larger, and in the early part of the nineteenth century it was about 8 tons per ton of pig iron. By various improvements, principally in the increase of the size of the furnaces and greater efficiency of the blast, it was reduced in 1833 to 4 tons, and in 1850 to 3 tons. With the utilization of the waste gases the consumption of coke was again rapidly reduced; probably nowhere more than in the huge American furnaces. At the Duquesne works, near Pittsburg, in 1899, each furnace produced 600 tons of pig iron per diem, with a consumption of 0·77 tons coke per ton of pig iron produced.

With this figure the limit of possibilities seems to be nearly reached, and we must look for further savings in other directions. One promising field has been found in the utilization of the furnace gases in gas engines for the production of motive power, instead of burning them beneath steam boilers and employing the steam in a steam engine. The laws of thermodynamics teach us that the potential energy of the fuel is but very imperfectly exhausted in the steam engine, owing to the low gradient of temperature in the steam cylinder. Carnot's theorem states that in a cycle of two isothermal operations and two adiabatic operations, the proportion of the work done in the cylinder to the thermal energy employed is expressed by $1-\frac{T_2}{T_1}$, where T_1 and T_2 stand for the absolute temperatures, between which the fluid oscillates. Every diminution of the higher temperature T_1 diminishes the yield. For instance, with steam at 180°C. cooled to 40°, the maximum yield would be $1-\frac{313}{453}=31\%$. On the other hand with fuel gas at 1,200°C., and allowed to cool in a gas engine to the same temperature of 40° (which is certainly impossible), the figure would stand at $1-\frac{313}{1,473}=79\%$; and if we allow a cooling to 500° (which is quite practicable), we still find a better yield than in the steam cylinder, *viz.*, $1-\frac{773}{1,473}=48\%$. This shows that the steam boiler is the prime cause of the low yield, by the diminution of the upper limit of the temperature in the working cylinder from 1,200 to 180°C. Of course neither of the calculated yields, 31 or 48%, can be realized in practice, but the calculation in general shows that in theory (which has also been fully borne out in practice) the heat given out by the burning fuel is much better utilized in a gas engine than in a boiler and steam engine.

The application of this theory to the utilization of blast-furnace gases would have seemed chimerical 30 years ago at the first appearance of the gas engine, when it consumed more than 1 cu. m. of that costly fuel, coal gas, per horse power hour. But during the last 10 years great progress has been made in this field, and about five years ago the economic use of blast-furnace gases began. The first gas engine driven by blast-furnace gas is probably a 30 H.P. motor, erected toward the end of 1894 by the Glasgow Iron and Steel Co., at Wishaw; in Great Britain, but the subject does not seem to have received much attention until quite recently. Germany and Belgium followed suit, a few months after, by setting up gas engines at Hoerde and Seraing. Other gas engines erected in Germany were the Oechelhäuser motor, the Deutz motor and the Dessau motor, ultimately up to 600 H.P. At Seraing, Belgium, Adolphe Greiner, the general manager of the Society Cockerill, employed an engine constructed by Delamare-Deboutteville and Malandin, which was later developed into a type called the "Delamare-Deboutteville and Cockerill" engine. In 1898 a 200 H.P. motor (according to this system) was constructed, and in 1899 a 600 H.P. motor. The results obtained therewith have been so satisfactory that the Society Cockerill now has orders on hand for 71 gas engines, representing an aggregate of 35,000 H.P., and is making preparations to build engines of a capacity up to 2,500 H.P.

It is a well known fact that blast-furnace gases carry away a large quantity of dust, amounting in some cases to 20 or 30 tons a day or even more, and naturally fears were entertained at first that this dust would give trouble in gas engines, perhaps altogether preventing the use of the gases in this manner, unless they were first submitted to a costly purifying process. This fear has now been dispelled and by the means ordinarily employed for purifying the gases previously to their use in Cowper stoves, etc., *viz.*, dust chambers and scrubbers, the dust is removed to the low limit of 2 g. per cu. m. At Seraing scrubbers are not even employed, a few Koerting injectors being placed in a separate chamber behind the dust chamber to cool the gases, and thus increase the density. This simple arrangement, which has already existed in connection with the Cowper stoves, has been quite sufficient for the use of the gas in gas engines, providing they had been constructed with special cylinders and valves for this object.

A record of the Seraing engines was obtained by a trial made at the works on March 20 and 21, 1900, in the presence of a representative committee of members from various nations invited to the testing. Some of the results obtained on that occasion are subjoined from the reports of Prof. Hubert of Liège and Prof. E. Meyer, of Göttingen. On March 20, the gas, which was found to yield in the calorimeter 950 heat units per cu. m., when employed in the Delamare-Cockerill engine, indicated work amounting to 26·1% of its total heat capacity, or 19·0% as effective work at normal load, and with a full load 26% of indicated or 21% of effective work. On March 21, the engine was worked without a break, and when directly coupled with a blowing engine, the gas yielded 965 heat units in the calorimeter. In this case 28% of the total heat capacity was converted into indicated, and 21 to 22·9% into effective work; the latter figure being nearly twice the work done by the best steam-driven

blowing-engines. Prof. Meyer testified that the gas engine worked with perfect regularity and reliability.* During several hours as much as 900 indicated or 725 effective H.P. were attained, with a consumption of 2·853 cu. m. of gas. This is very much better than would have been considered possible two or three years ago.

At Donnersmarkhütte the following results were obtained with a four-stroke 100 H.P. engine, supplied by Körting Brothers, as an average of five months' work. At full load the engine consumes 2·70 cu. m. blast-furnace gas, at half-load 3·1, at third-load 3·5 cu. m. of gas per effective horse power hour. This engine gives full satisfaction as to the regularity of the work. The quantity of water used, including the amount employed for washing out the dust, is from 80 to 100 cu. m. per day, the consumption of oil is 2·75 kg. per day.† The results obtained at Friendenshütte‡ with a 200 H.P. engine of the Deutz type are reported as being perfectly satisfactory. This is all the more remarkable, as the Deutz engines were directly coupled with a dynamo on the tri-phase system.

At Seraing, where the heat value of the gas is not very high, the pressure in the gas engine may reach 8 or 10 atmospheres, and on March 21, 11 atmospheres was recorded. This fact disposes of the fear that the dimensions of gas engines working with poor gas are required to be inconveniently large. In this respect it must be also borne in mind that blast-furnace gas requires less air for its combustion than coal gas, and it has been calculated that an engine working with poor gas produces 0·74 of the amount of work it would produce with coal gas. In this connection practice has outrun calculation, for at Differdingen a gas motor, which had formerly yielded 80 H.P., with coal gas, yielded 67 H.P. with blast-furnace gas. Any fear in this respect must vanish in the face of the fact that there exist at this moment so many engines up to 700 H.P., which are operated with blast-furnace gas. Nor need fears be entertained on account of the variations of pressure of the gases; at Seraing, when the pressure between 45 and 62 cm. of mercury suddenly was changed, the only effect was a retardation of the movement. The ordinary speed of the present type of gas engines for this purpose is 100 strokes per minute which allows them to be coupled directly with blowing engines constructed on modern principles and provided with Corliss, Horbiger or Riedler valves.

The following are the dimensions of the coupled 600 H.P. gas- and blowing-engines of the Seraing type:

MOTOR: Diameter of cylinder, 1·3 m.; stroke, 1·4 m.; diameter of piston rod, 0·244 m.; diameter of main shaft, 0·460 m.; space occupied by motor: length, 11 m.; width, 6 in.; height above floor, 4 m.; weight (inclusive of 33 ton fly-wheel), 127 tons; normal pressure, 9·5 atmospheres.

BLOWING ENGINE: Diameter of cylinder, 1·7 m.; stroke, 1·4 m.; diameter of piston rod, 0·244 m.; space occupied: length, 5·5 m.; width, 3·5 m.; height above floor, 4 m.; weight, 31 tons.

TOTAL: Space occupied: length, 16·5 m.; width, 6 m.; height above floor, 4 m.; total weight, 158 tons.

* *Gas Journal*, p. 852, 1900. † *Stahl und Eisen*, April 15, 1900. ‡ *Ibid.*

The engine is a four-stroke, with simple effect. The horizontal cylinder consists of two parts, bolted together, one forming the combustion chamber and provided with distributing valves and a slide, in which induction sparks produce the ignition of the gases; the other part contains the piston which moves backward and forward. The engine is connected with the main shaft and fly wheel, and on the opposite side it carries a rod, which passes through the combustion chamber and drives the piston of the horizontal blowing engine. All parts exposed to the gas, including the valves, piston and rod, are cooled by water. Two valves of a size exactly proportioned to the volumes of gas and air to be admitted, move simultaneously and allow the gas and air to pass into a chamber that is provided with a larger valve. The mixing chamber alone receives the explosive pressure and thus protects the first two valves.

The necessarily limited character of this article precludes the discussion of other types as constructed at Deutz, by the Berlin Anhaltische Maschinenbau Aktien Gesellschaft, and by Oechelhäuser; also the much discussed question whether it is preferable to employ engines with one or with more cylinders. It may be interesting to note that an American firm is negotiating with the Cockerill Co. for a 500 H.P. engine, to supply a blast furnace that produces 800 tons of pig iron per day, working at a pressure of 1,250 mm. mercury. This work can be performed by coupling, tandem fashion, two groups of four cylinders each, similar to those now in use at Seraing.

Considering that the above discussion of the construction of gas engines for dealing with the largest blast furnaces is sufficient, a few words on the profit which the ironmaker may derive from this source will prove of interest and value.

According to recent authorities it may be assumed that a blast furnace yields for each ton of pig iron produced about 4,500 cu. m. of gas, representing between 800 and 1,000 heat units per cu. m. Prof. Hubert quotes detailed statements of results, obtained by M. G. Rocour, which prove that the heating power of the exit gases represent from 46 to 55% of the heating power of the coke charged into the furnace, the average being 50·5%. Of this a little more than a quarter suffices for heating the blast, leaving about 37% of the original heating power of the coke at disposal for other purposes. If these 37% are utilized in gas engines, about 31 H.P. can be obtained for each ton of pig iron produced per day.

Prof. E. Meyer arrives at a slightly lower result, on the following basis. His well-known experiments with a Dowson gas engine made at Basel showed a consumption of 0·635 kg. coke per indicated horse power hour. The coke in that case contained 87·7% C; the yield of the gas producer was 71·3%. Regarding, as we may do, the blast furnace as a gas producer with a yield of 37% (after performing its duty as an iron making apparatus), and allowing (as Meyer does) a thermal yield of only 19% for the gas engine, the average yield of the blast-furnace gases in the shape of power comes out=29 indicated horse power per ton of pig iron made per day, the effective horse power averaging 23·2.

A part of this mechanical power is required for the service of the furnace itself. Rocour puts the power for driving the blowing engines at from 260 to

362 H.P. per 100 tons of iron, according to the pressure of blast employed, and averages it at 310 H.P. To this must be added 30 H.P. for accessory services, thus leaving per 100 tons of iron 2,320—340=1,980 H.P. at disposal for other purposes.

If we burn the same gas under a steam boiler, the thermal yield would not exceed 60% in the shape of steam. Assuming a consumption of 12 kg. steam per H.P., the requirements of the blast, etc., leave only 370 H.P. per 100 ton iron at disposal for other purposes; but for high pressures of blast in reality no excess whatever would remain. At all events a surplus of 1,600 H.P. per 100 tons iron is obtained by the use of the gas in a gas engine, in place of a steam boiler.

F. Lürmann makes the following calculation: 4,633 cu. m. of gas are obtained per ton of pig iron, of which 10% is lost at the furnace mouth and in the conduits, leaving 4,170 cu. m. available for use. For heating the 4,136 cu. m. of air required for each ton of iron from 20 to 850°C., assuming a yield of 85% in the Cowper stoves, 1,300 cu. m. or 31·7% of the above volume of gas is required, leaving 2,870 cu. m. at disposal for the production of mechanical power. If we burn this gas under a steam boiler, with a temperature of 300°C. in the chimney, with a yield of 70% in the boiler, a consumption of 10 kg. of steam at 8·5 atmospheres per horse power hour and a consumption of 60 kg. of steam per ton of iron, we retain only the equivalent of 346 H.P. per 100 ton of pig iron. But if we burn the whole of the above 2,870 cu. m. of gas in a gas engine, a surplus of 2,816 H.P. remains over and above the engine power required for the service of the blast furnace. This calculation of Lürmann's leads to a very high figure in favor of the gas engine. The results of other calculations show a somewhat lower result. Demange finds a surplus of 1,980 H.P. per 100 tons of iron. A. Greiner, with very unfavorable assumptions and on the basis of the consumption of 3·5 cu. m. of gas per effective horse power hour, arrives at a surplus of 2,000 H.P., and Prof. Hubert at 1,950 H.P., these two latter authorities practically agreeing with Rocour.

This gain of power does not mean merely a corresponding saving of coal, but also less interest and amortization on capital, as the cost of steam boilers and engines is much higher than that of gas motors; the cost of labor is also higher in the former case. The total saving in the conditions of Belgian industry is calculated by Hubert at 8 fr. per ton of iron. In America, with cheaper coal, it cannot be less than $1 per ton of iron.

From the above may be seen that the surplus of 20 H.P. per ton of iron can be utilized for extraneous purposes, probably for the production of electrical energy, for lighting purposes, etc., and while it may not be possible in every locality wherever there is an outlet for mechanical or electrical power, the saving produced by the new system runs into very large amounts.

The Utilization of Lignite in Germany.

By Paul Krusch.

From the beginning of lignite mining, all attempts to utilize waste coal dust had failed until the discovery was made of the process by which it is turned into the so-called "compressed coals." Its utilization in this manner has developed an industry that has now grown to considerable proportions.

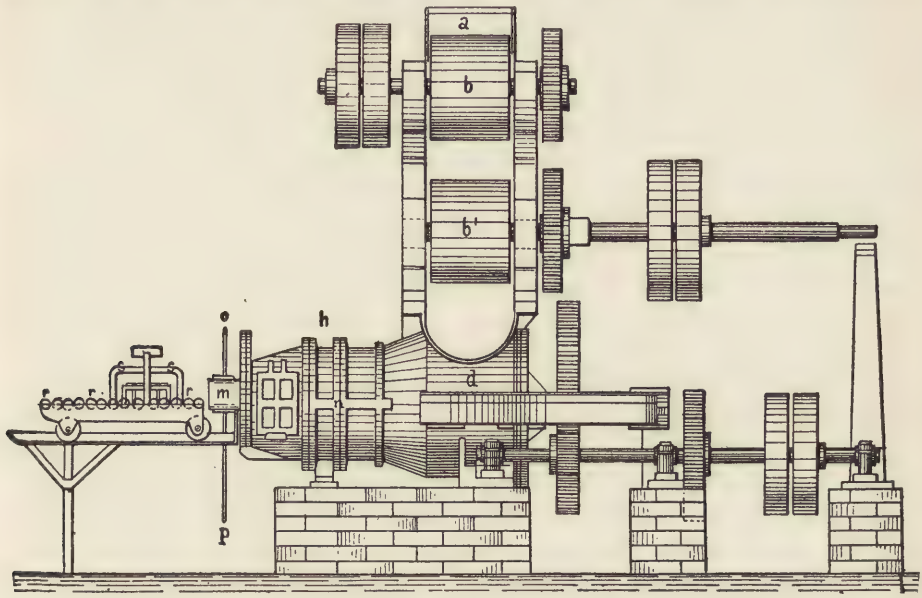
The Manufacture of Compressed Lignite.—At first the coal dust admixed with a small amount of clay was moistened and stamped by foot into a uniform pulp which was then pounded into wooden frames 21 cm. long and 10·5 cm. wide, and allowed to dry in the air. Later in the Rhine province a large part of the earthy lignite product was formed into truncated cones 20 to 26 cm. high. The coals so formed were of inferior heating value and very friable. In time the machine production of compressed coals developed, in which two kinds of product are distinguished, the wet compressed coals and the dry compressed coals or briquettes; the former made from coal wet from the mine and the latter from coal dried before treatment. The wet compressed coals are brick shaped with rounded edges. They contract from 20 to 25% in the drying process and are about 20×8·8×5 to 6 cm. in size, with a corresponding weight of 1 to 1·3 kg. The dry compressed coals or briquettes are of similar shape and much smaller, 15 to 18×6 to 8×3 to 4 cm. and weighing 0·3 to 0·5 kg. The specific gravity of mine damp coal is from 1·22 to 1·29; that of hand-molded coal is from 1·24 to 1·31; while wet compressed coal is from 1·26 to 1·32 and dry compressed coal from 1·2 to 1·22.

The wet compressed coals have an earthy appearance, and when thoroughly dried are traversed by minute cracks. The dry compressed coals are covered by an air-tight crust which has a dull luster on the broad faces and a marked luster on the others. The fracture is porphyritic, showing a dense, dark ground mass with brighter grains of coal. About 75 hl. of mine damp coal are required for 1,000 dry compressed coals. The process of briquetting increases the absolute heating power of the crude coal 26 to 37% in the wet compressed coals, 39 to 66% in the briquettes; and were it possible in the process of manufacture to reduce further the water content, which in wet compressed coals amounts from 22 to 30%, and in dry compressed coals from 12 to 21%, the practical heat value would be considerably increased. The breaking load for 1 sq. cm. of unsupported cross-section, amounts to 13 kg. in the briquettes of the Province of Saxony; 14 to 17 kg. in those from Rodden mine at Cologne, and 14 to 20 kg. in those from Bruehl.

The wet compressed coals burn much better than the hand-molded ones, but as their manufacture is limited to the summer months the bricks which lie in storage all winter become dried to such an extent as to render them unfit for rail transportation. The dry compressed coals will admit of long storage and will stand a long shipment with but little waste. The small quantity of sulphur present and their handy size and shape, make the briquettes well adapted for house use. Their use has been limited in the industries, because of their tend-

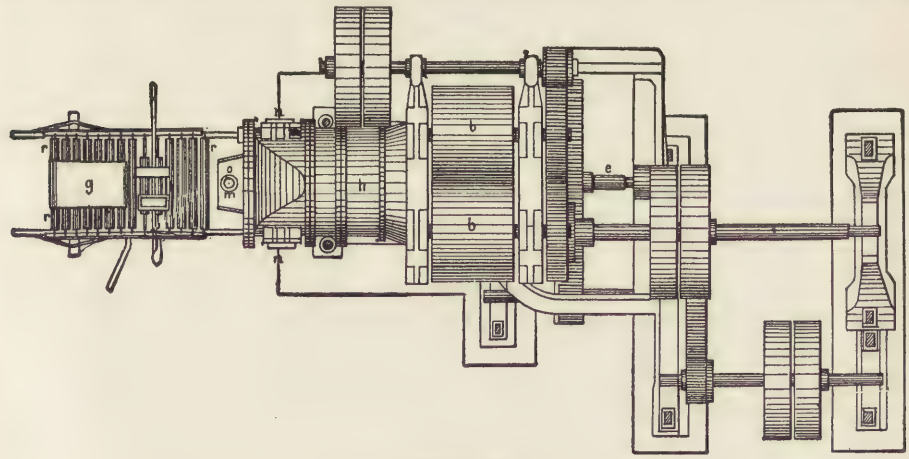
ency to disintegrate when raked. The market for wet compressed coals has been limited and is constantly diminishing, especially in the Province of Saxony.

THE MANUFACTURE OF WET COMPRESSED COALS.—For compression, an earthy coal is used, which occurs in the Provinces of Saxony, Brandenburg,



(Elevation.)

bb^1, Pulverizing rolls. *d*, Kneading apparatus. *h*, Compression cylinder. *m*, Outlet. *r*, *r*, *s*, *s*, Cutting device.



(Ground Plan.)

FIG. 1.—THE HERTEL-SCHMELZER'S WET-COAL PRESS.

Silesia, on the Rhine, and in the Kingdom of Saxony. It is clear, dark brown, and in its mine damp condition contains from 40 to 60% of water, and from 35 to 50% of combustible material. It disintegrates when dried in the air into small coal and coal dust, the larger pieces of coal in the mine being only

from 10 to 15% of the whole mass. The process of manufacture,* perfected by L. Schmelzer of Magdeburg is as follows: (1) The production of a plastic coal pulp; (2) the compression, by means of which an uninterrupted stream of coal issues from the mouthpiece of the press; (3) the cutting of the coal stream into compressed blocks; and (4) the drying of the compressed coals. In the first three operations, the Hertel-Schmelzer (see Fig. 1) machine is used. This consists of a crusher, a compressor connected with a kneading machine, and a cutter which allows continuous action. The sieved lignite is mixed with half its weight of water and the pulp passed to the disintegrator below, which usually consists of two pairs of smooth, hollow, chilled, cast-iron rolls, placed one pair above the other. The shafts of the upper pair of rolls are rubber cushioned, which allows a separation of 20 cm. during the passage of large pieces. The lower pair of rolls crush finer and revolve much faster than the upper. The fine coal, from the rolls, passes through the kneading machine into the compressor. The kneading machine consists of a horizontal cylinder with a conical taper, which is either cast in one piece or screwed on to the actual compression cylinder. A revolving shaft passes through both cylinders, making from 15 to 20 revolutions per minute. Two screw conveyors, placed opposite each other mix the fine coal, a third conveyor passes the mixture through the conical part of the kneading machine into the compressor, where two screw conveyors pass the coal into the front part—the so-called "accumulating" chamber. From this section the coal pulp is forced out through the attached mouthpiece or "form piece" by the pressure of the new material which is being constantly added. This mouthpiece is 21 cm. long, rectangular in cross section, with slightly rounded corners, and somewhat conical in front. Its sides are steam heated to 100° C., to give the coal stream by the more thorough drying a greater strength as it passes out. The coal stream passes to the cutter which is so arranged that the forward motion of the coal is not interrupted during the cutting. A lifting apparatus attended by one man cuts three blocks of about 6·2 cm. length at one time. The finished compressed coal blocks are stored in drying sheds and dry in from 8 to 10 days. In dry air they generally contain from 22 to 30% of water. Splint coal will give more compact blocks with greater heat value than earthy fat coal, and naturally coals of a dry, woody constitution are least adapted for this process. For the production of one ton containing 1,000 pieces of wet compressed coal, 1·66 tons of crude coal may be allowed. The newer machines produce daily up to 80,000 pieces of wet compressed coal; the annual production of a large press is estimated at from 7,000,000 to 10,000,000 pieces, work being carried on only during the summer months. At Teuchern and Deubern, special dryers are used. The first cost of a complete factory with a daily output of 35,000 wet compressed coals, is estimated at from 40,000 marks to 42,000 marks (about $10,000 to $10,500), and the cost of manufacturing 1,000 pieces (1·085 kg.) is estimated at 3 marks ($0·75).

THE MANUFACTURE OF DRY COMPRESSED COALS (BRIQUETTES).— Mine damp

* For a complete description of the machines for mixing and pressing coal briquettes, see THE MINERAL INDUSTRY, Vol. VI.

coal is disintegrated, thoroughly dried, compressed under great pressure and baked into briquettes; the bitumen of the coal melts under the heat of compression, and binds the separate coal particles into a solid mass. It is therefore unnecessary to add foreign cementing material. The amount of bitumen or tar present in lignite free from water varies between 3 and 30%, and the degree of dryness and amount of compression must be adapted to the amount present. The softest lignites with high water content give the most durable briquettes.

The coal grains should be uniform in size for compression, and moisture in excess of the amount necessary for the production of durable briquettes should be removed. Every dry coal factory consists of three separate divisions besides the boiler house: (1) The sorting house, (2) the drying house, and (3) the compression house. It is estimated that for one press working 12 hours from 20 to 30 tons of raw coal, previously sorted and dried, will be required.

The Sorting of the Raw Coal.—In Germany this work is called "kohlennassdienst" (wet coal service). Its purpose is to give to the mine damp coal the uniform fine-grained condition which is necessary for thorough drying and compression. The presence of large pieces is just as harmful as too complete disintegration into dust. The raw or "bright" coal is brought to the upper floor of the sorting house, where it is either sorted by trommels and flat screens before disintegration, or is dumped directly through a funnel-shaped receiver into the disintegrating apparatus below. Here it first comes to a slowly turning roller having several ribs or carriers on its periphery, which uniformly supplies two shaking screens placed beneath, with a mesh width of 10 to 15 and 30 to 50 mm., respectively. From the screens the finest material passes into the drying apparatus, the medium sized passes to a crushing apparatus below the screen, and the coarse kind is removed and sold. The crushing apparatus consists of an arrangement of rolls similar to those used in the wet compression plants.

The Drying of the Raw Coal.—The treatment varies with the composition of the coal; if rich in bitumen, a lower heat is required than when the amount of bitumen is small; the amount of water present also affects the operation. Coals that bake on heating and give off dust when thoroughly dried require a kiln with a strong draft and little heat. This disintegrated coal dust falls on an elevator, which returns it to the coal loft of the drying house, where it is resized to remove the lumps. The kiln may have a mechanical or an automatic movement of the coal, and the heat for drying may be produced by steam, by direct firing or by hot air, either in direct contact with the coal or applied indirectly by means of heated surfaces. The draft required is produced by a chimney or an exhaust fan, and removes the gases and the steam. The circulation of the hot air used for drying takes place in various ways. The stream may be divided evenly over the total height of the apparatus, or counter streams employed; in which case the coals to be dried move from top to bottom against the upward passage of the heated gases, and may become dried too thoroughly. For this reason the parallel stream principle is used in the newer ovens, in which the gases move in the same direction as the coal. These apparatus may be divided in the following manner:

1. *Drying Apparatus with Mechanical Movement of the Coals.*—(*a*) Steam ovens: Circular steam ovens (steam slide drying ovens), Vogel's steam slab oven, and Schulz's pipe or flue apparatus. (*b*) Fire Ovens with Direct Heating: Mulder oven, circular fire oven (Riebeck's circular oven), and an indirectly heated oven (Kubisch's cylindrical oven).

2. *Dry Apparatus with Automatic Movement of the Coals.*—Fire ovens with direct heating (Leutert's chambered drying oven), wind ovens (Rowold's wind oven), and ovens with combined heating (Jacobi's pipe dryer).

Of these the circular steam ovens, the circular fire ovens, Rowold's wind oven and Jacobi's pipe dryer are generally used. It is very difficult to decide which is the best drying apparatus. That type in which the coal glides down automatically is adapted for granular coal only, and gives a poor result with dusty or damp coal; on the other hand, those with mechanical movement of the coal will work with coal of any size. Coal rich in bitumen requires a low drying heat, while coal poor in bitumen calls for a high heat; in the former case, therefore, the steam and wind ovens are preferable, while in the latter, the fire ovens should be used. As regards the safety of the operation, it depends on the danger of fire and explosions; both increase with the rise in temperature and with the formation of dust. In this connection, the steam slab ovens and circular steam ovens of the latest construction are relatively the safest, because the temperature is moderate and the dust is removed by means of the strong draft. These steam ovens possess an additional advantage in that their operating expenses are small, as they use exhaust steam only and require the least attention. As the drying cannot keep pace with the compression, which is liable to interruption, and as the coal must have a definite degree of temperature for compression—soft coal is compressed at a higher temperature than hard coal—storage rooms are necessary, although they present the drawback of danger from fire.

Pressing the Briquettes.—The Exter press is generally used for pressing the briquettes, and reference for its construction details should be made to Bjorling's article on the "Manufacture of Briquettes" in THE MINERAL INDUSTRY, Vol. VI. The production of one press is 72,000 briquettes, weighing from 24 to 36 tons, per day of 20 hours. Upon leaving the press the briquettes are hot and in a sweating condition. They lose several per cent. in weight and expand about 3% of their length in cooling. To prevent spontaneous ignition they are passed over a long route to the store room and are there piled up with horizontal and vertical air channels left among them. The solidity of the briquettes depends more or less upon perfect cooling, and special apparatus has been designed by J. Werminghoff, F. A. Schulz, and Vogel & Co. to accomplish this desired effect.

For the operation of two briquette presses steam boilers are required having from 100 to 160 sq. m. of heating surface. The amount of coal consumed varies with the system of ovens employed and the constitution of the coal. In the official mining district of Halle it amounts to from 27 to 30% of the lignite used in the production of the briquettes. For the production of one ton of dry compressed coal about 2·25 tons of raw coal are necessary, of which 0·48 tons are used for fuel and the rest for the briquettes.

Tralls' Method of Briquette Manufacture.—In order to reduce the cost of manufacture, Tralls (Furstenwalde) has invented a process by which the coal is dried only to the dryness of the atmosphere. The dried coal is disintegrated by rolls and filled into the forms through a funnel. These forms are depressions in a wrought iron disk, which rests in the center on a revolving pin and at the circumference on small rollers running in a special path. A steam hammer falls on the plate, whose iron lower part fits into the forms, and, after each blow, the disk is turned by a lifting apparatus 0·125 or 0·0625 of a revolution, depending upon the number of the forms. The finished briquettes are pushed out by an automatic pressure appliance. With a single stroke 30 pieces per minute are produced, which corresponds to 18,000 pieces per day of 10 hours. The first cost of a dry compress coal factory, with two presses which will deliver 3 tons of briquettes per hour, or 60 tons per day of two shifts, is from 200,000 to 300,000 marks ($50,000 to $75,000). The cost of manufacture, not including the cost of raw coal, is from 4·85 marks to 6·30 marks ($1·25 to $1·60) per ton of briquettes. Interest and sinking fund are calculated at 10%.

PRODUCTION OF LIGNITE AND BRIQUETTES IN PRUSSIA.

	District of the Mining Department.	Production of Lignite. Metric tons.	Value of material mined. Marks.	Number of workmen.	Number of briquette presses.	Briquettes produced. Metric tons.	Number of wet press machines	Coal worked into wet press stones. Metric tons.
1897.	Breslau	537,427	1,819,726	1,391				
	Halle	21,008,684	46,293,171	26,955	329	*a* 1,924,963	79	*b* 762,971
	Clausthal	445,556	1,524,000	1,404				
	Dortmund							
	Bonn	2,288,643	3,656,778					
1898.	Breslau	602,547	2,047,468	1,391				
	Halle	22,265,628	49,068,252	28,270	341	*a* 3,217,336	79	*b* 764,965
	Clausthal	442,603	1,549,050	1,445				
	Dortmund							
	Bonn	2,753,765	6,499,538	3,024				
1899.	Breslau	644,333	2,307,250	1,499				
	Halle	23,386,350	51,402,066	29,085				
	Clausthal	444,736	1,720,157	1,491				
	Dortmund							
	Bonn	3,984,499	8,076,574	3,899				
1900.(*c*)	Breslau	612,707		1,605				
	Halle	19,653,194		38,995				
	Clausthal	360,364		1,661				
	Dortmund							
	Bonn	3,713,598		5,756				

(*a*) For the production of 1 ton of briquettes was required of coal for drying: 2·22 tons in 1898 (1897, 2·20 tons) and of fuel coal 0·90 tons. The average yearly output for 1898 of a press amounted to 9,435 tons against 8,890 tons in 1897 (*sic*). (*b*) On an average 1 wet press machine worked 9,683 tons of crude coal in 1898 against 9,658 tons in 1897 (*sic*). The 17 most important establishments produced 405,744 tons of wet pressed stones in 1898; to this must be added 15 establishments with 10,000 to 15,000 tons; 17 with 5,000 to 10,000 tons and 10 with 5,000 tons. In 1898, 5,231 persons were engaged in the production of briquettes, wet pressed stones, and hand formed stones, against 5,209 in 1897. (*c*) From Jan. 1 to Sept. 30, 1900.

The Destructive Distillation of Lignite.—The manufacture of mineral oils from the brown coal has been carried on in different parts of Germany since the middle of the present century. To-day the Province of Saxony has developed the industry to a very efficient state, and bears creditable comparison with the large industry in Scotland. Of all the varieties of lignite, the so-called "Schweelkohle" is best adapted for the purpose of destructive distillation. By this is understood an earthy coal very rich in bitumen, which is found especially in the neighborhood of Weissenfels, Zeitz; near the Mansfeld lakes; near Aschersleben, Halberstadt, and Halle, and is associated with common lignite. The

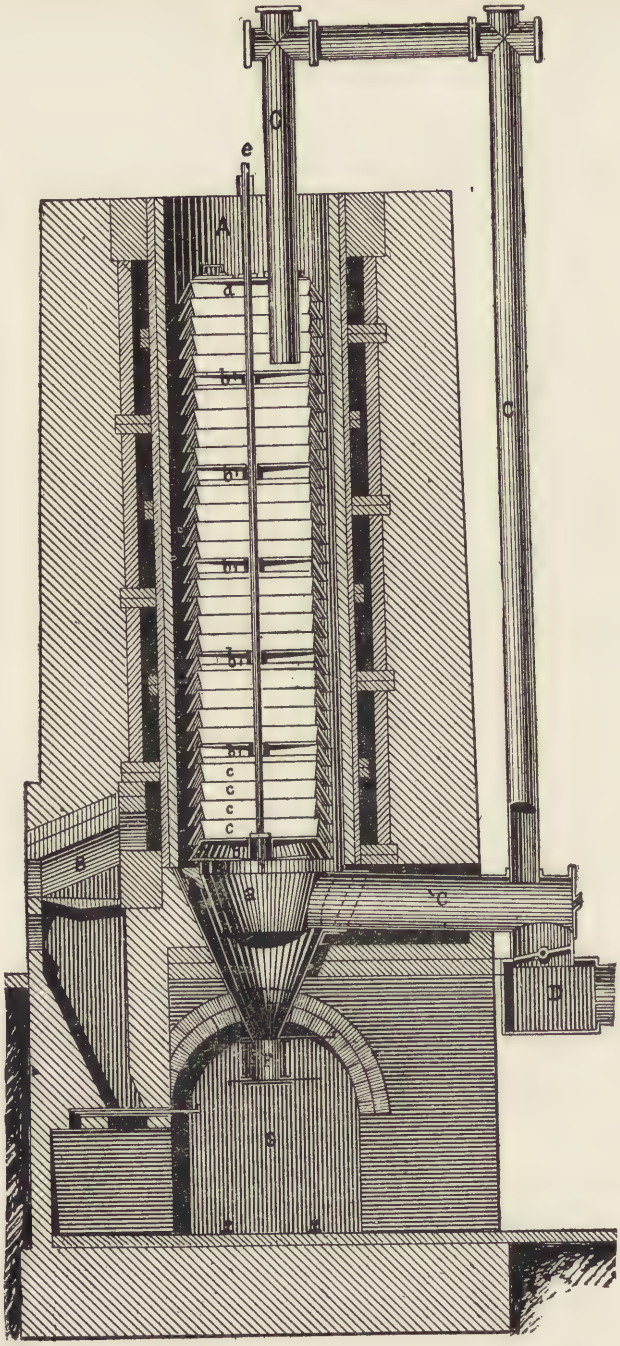


FIG. 2.—ROLLE'S VERTICAL RETORT.

$b_1b_1b_1b_1b_1$, Brackets for the superposed rings. *C*, *C*, *C*, Pipes for the gases. *c*, *c*, *c*, *c*, Series of rings. *d*, Cover to bell space. *e*, Axis supplied with brackets to hold the bells in position. *F*, Cylindrical box at the bottom of the cone.

"Schweelkohle" deteriorates on exposure to the air, and its yield of tar considerably decreases, probably through oxidizing processes. For this reason the coal employed for distillation should be as fresh as possible. In Saxony a coal which yields as low as 5% tar is considered worth working.

The Process of Destructive Distillation and Its Apparatus.—Great care and experience are necessary for the management of a distilling plant, as entirely different distillation products are obtained by using different temperatures. When too strongly heated many gases and aromatic combinations are produced, while on the other hand, when the temperature is too low many heavy hydrocarbons are formed and a large part of the carbon remains in the residue as coke. Distillation is always begun with a low degree of heat, which is gradually raised, and finally brought to such a point that the last remnant of the bitumen is driven out. The retorts in use are for the most part of the vertical type, and were originally constructed by Rolle in 1858 for distilling lignite. They are from 3·75 to 6 m. high, from 0·94 to 1·90 m. in diameter and are provided interiorally with a system of superposed rings (Glocken) *c* (see Fig. 2) enclosing a cylindrical space which is connected with the outer oven-space through the intervening spaces between the rings. The ring space is closed on top by a cap *d*, placed 0·50 m. below the top opening of the oven. The lowest ring is conical, and conforms to the lower part of the oven on which it rests. Attached to the bottom of the oven is a cylindrical chamber *F*, of 1 to 2 hl. capacity, which is closed on top and bottom by a slide plate. A pipe at the top *C*, and another at the bottom lead the gases from the "Glocken" cylinder to the receiver, *D*, and the condenser.

The coal is shaken on to the cap of the cylinder and passes slowly down the annular space between the ring cylinder and oven cylinder; it is distilled in the passage as the mantle is surrounded with heated gases. The gases of distillation pass into the ring cylinder and are led into the receiver through the escape pipes mentioned above, *C* and *C*, and from thence to the condenser, their passage being accelerated by a fan or Koerting's exhaust. The coal passing downward is deprived of its gases and reaches the lower part of the cylinder as coke, and on opening the slide it falls into the cylindrical chamber beneath, *F*, and is removed therefrom by closing the upper slide and opening the lower one, without disturbing the continuous operation of the oven. The fire bricks for the construction must not be affected by the ash and must withstand the highest temperature without melting. The stoves were made at first entirely of iron; later they were made more durable by a covering of fire bricks arranged in a double ring with flues. The iron cylinder of the stove is from 4 to 5·5 cm. thick and the fire bricks conforming to the curvature of the cylinder are 26 cm. long, 8 cm. wide and 5 cm. thick. At a later date the iron cylinder was entirely replaced by fire brick, which gave greater durability but had the disadvantage that diffusion occurred between the gases of distillation rising in the oven and the heating gases outside. In this construction the whole cylinder is surrounded at a distance of 10 to 20 cm. by a fire-brick mantle, and in the intermediate space, which narrows toward the top, the gases from the fire cir-

culate in directions determined by the wedge-shaped fire bricks placed in the space.

Until a few years ago the vertical retorts in the Province of Saxony were heated with coal fuel on iron grates; at present probably one-half of the ovens in Saxony are heated by the gases given off during the distillation which have been almost completely freed from the fluid hydrocarbons in the condenser. These gases are passed through a cooling apparatus and burned in the grate, in the flues, or in both. An automatic stop interposed between the fire and the condenser prevents explosions. Generally 12 adjacent ovens form a battery, and have in common a front and rear wall, a receiver, condenser, and exhauster. The place from which the single ovens are supplied with coal is called the distilling loft. Two batteries opposite each other have a common stoking place, which is supplied with coal fuel through funnels from the distilling loft. The pipes of the condensing apparatus are of sheet iron 3 mm. thick, and of several widths, 90, 50, 40, 30 and 25 cm. Cooling is accomplished by the air contact with the long distance of piping through which the gases travel. All products of condensation pass into the tar accumulating pit (receiver), from which the separated water flows through a pipe. The coke as it comes from the oven has a temperature of 400° C., and is extinguished in pits by water. The stoves are cleaned every four or six months, and for this purpose the fires are extinguished and the gases drawn out by an exhaust before the stove is opened. The highest permissible temperature of the distilling ovens for lignite is 900° C., and when thus heated the gases of distillation leave the stove at a temperature of 120 to 150° C. In 24 hours 20 to 35 hl. of coal are distilled in one retort, depending upon its diameter; each retort represents a capital of about 5,000 marks ($1,250).

Products of Destructive Distillation.—In the process of destructive distillation of lignite four products are obtained, *i.e.,* tar, gas, water and residue. The tar consists of solid and liquid hydrocarbons, a small quantity of aromatic acid and basic bodies, oxygenated products not yet definitely characterized, aldehydes and organic combinations with sulphur. Its specific gravity at 35° C. is 0·820 to 0·950; it solidifies between 15 and 30° C., and is brown or black in color; at ordinary temperature it resembles butter. When melted it possesses a dark green fluorescence, and sometimes gives a strong odor of hydrogen sulphide. The boiling points of the various components in the tar range from 80 to 400°C., and in distillation the principal quantity passes over between 250 and 350°C. In Saxony and Thuringia the gases of distillation consist of a 10 to 20% CO_2, 0·1 to 3% O, 1 to 2% heavy hydrocarbons, 5 to 15% CO, 10 to 25% CH_4, 10 to 30% H, 10 to 30% N, and 1 to 3% H_2S. The average retort gas is used to heat the retorts. The water of distillation is unimportant. It contains only a small amount of ammonia and has a weakly alkaline reaction. It is of reddish brown color and has a sp. gr. of from 2 to 3°B.

The coke ("Grudecoke") has a granular structure, black color, and contains 15 to 45% of ash. It furnishes an excellent fuel in ovens arranged for its use, and is an important source of revenue to the distilling works. When the amount of ash is small these cokes are of value in the chemical industry, as they can be worked up into a black dye. The coke is also used as a reducing agent in

metallurgy, as a waste water filter in distilling factories, and when finely ground as a decoloring and disinfecting agent. When cemented it forms good briquettes.

THE INDUSTRY OF SAXONY-THURINGIA.—From the distilling establishment the lignite tar passes to the mineral oil and paraffine factories, whose work is divided into three parts: (1) Distillation, (2) Treatment of the distillates with chemicals, and (3) Manufacture of paraffine.

The Distillation.—The tar is distilled in retorts and yields a series of products of different melting points. The cast or wrought iron retorts or stills are walled in and surrounded by gases from the fire. They are filled two-thirds full with from 2 to 3 cu. m. of tar, and are closed by a cast-iron cover which is screwed on. If the distillation takes place in a partial vacuum a pipe is attached to the bottom of the still which may be closed by a valve under the fire. From the still the vapors pass into a worm condenser, which is connected with two cylindrical receiving vessels having a capacity of 150 liters. The distillate is run off through a pipe at the bottom of the receiving vessels, which are exhausted by means of a Koerting's exhaust, producing a vacuum in the still. While one of the receiving vessels is being emptied the other is receiving the distillate.

In distillation without a vacuum, the still is filled through a manhole in the cast-iron cover, and 0·25 to 0·5% of slacked lime or pyrolusite is added to absorb the hydrogen sulphide produced and to lessen somewhat the amount of creosote. Distillation is continued to dryness, and the coke is cleaned out of the stills after cooling, or else the residues from several stills are put into a special still and then distilled to dryness. A charge of 1,200 kg. of tar distils for 10 hours and requires on an average 10 hl. of coal.

In vacuum distillation the stills are filled at the same time that the air is being exhausted. When commencing the distillation the air is but slightly exhausted, later the vacuum is increased, so that as soon as paraffine appears it corresponds to a column of mercury 40 to 50 cm. high. Three-quarters of the contents is distilled in 6 or 7 hours, and the rest is placed into the residue-still, where it is distilled to dryness. There may be 15 or 16 charges per week with night work. 2,000 kg. of tar require 8 to 9 hl. of coal for distillation, including the treatment in the residue-still. The vacuum distillation has an advantage over the ordinary process in that the decomposition of the distillation products is avoided and a purer paraffine is obtained.

By steam distillation is meant the distillation with steam at from 3 to 4 atmospheres pressure. The steam enters either the lower or upper part of the still in such quantities that about one-tenth of the distillate consists of water.

The distillation splits up the lignite tar into light crude oil and a paraffine mass, which separate as soon as the distillate solidifies on ice or on any cooled surface. The last paraffine is greasy and red; it is called "red" or "red products." The residue in the still is coke. During the distillation, gases pass out which are not condensed. Generally tar having a sp. gr. of 0·860 is used, and there is obtained some water, 30% of light crude oil, 64% of paraffine mass, 2% red products, 2% coke and 2% of gas.

Light crude oil is dark brown, smells like H_2S, has a sp. gr. of 0·85 to 0·86, and boils between 100° and 350° C. The paraffine is treated chemically when crude tar has been distilled. Its sp. gr. varies between 0·86 and 0·87; it contains 15 to 20% of hard paraffine. By compression hard scales and heavy crude oil are obtained. The red products have a sp. gr. of 0·9, contain but little paraffine and are added to a new charge of tar, without their mass increasing in the following distillation. The coke may be used as a fuel or in electrical work. The gases arising from distillation may be utilized for heating and those from the distillation of the paraffine mass for lighting.

The light crude oil is distilled in the same stills as the tar, with or without a vacuum, and with the addition of 0·25 to 0·5 of ground caustic soda. The separation of the fractions of the light crude oil is accomplished through their specific gravities. There is obtained: (1) Light lignite-tar oil (crude benzine), (2) light crude photogen, (3) light colored paraffine oil, (4) solar paraffine mass, and (5) coke.

The light, slightly yellow lignite tar oil has a sp. gr. of from 0·79 to 0·81, flashes at from 25 to 35° and boils at from 100 to 200°C. It is further chemically treated. By distillation with steam passing in at the bottom of the still it is separated into three fractions of a sp. gr. of from 0·76 to 0·82, which are used in refining paraffine. The light crude photogen has a specific gravity of from 0·835 to 0·840, flashes at from 30° to 40° C., is light yellow and soon becomes dark; the distillation following the mixing process takes place in the same stills and with the same addition as that made to the light crude oil. The light colored free paraffine oils, almost free from paraffine, have a sp. gr. of from 0·86 to 0·88, are yellow to red, and boil at from 220° to 320° C. They are either sold as such, or are chemically treated, or are again distilled. The solar paraffine mass having a sp. gr. of from 0·86 to 0·87 is crystallized in the cooling. The coke cannot be used as a fuel on account of the soda in it. In the oil distillation a greasy red mass passes over finally, which is placed with the red products and again added to the tar.

The light crude photogen is separated by distillation into (1) light lignite tar oil (benzine), (2) solar oil, which amounts to 50 to 60% of the total mass, and (3) light colored paraffine oil. The benzine is colorless, has a sp. gr. of from 0·79 to 0·805, and is treated like crude benzine. Solar oil has a sp. gr. of from 0·825 to 0·830, flashes at from 40 to 50°, is colorless, and is sold direct or chemically treated. The light colored paraffine oils are treated in a similar manner to the light crude oil.

The heavy crude oil which flows out of the paraffine mass when the paraffine is obtained, gives on distillation: (1) Crude photogen II.; (2) Solar oil I., and (3) Secondary paraffine mass; 3 to 4% of the crude oil charge is left over to form the mineral tar "goudron" which corresponds to the coal tar and is put on the market. A kind of asphalt may be made from it. Crude photogen II. has a sp. gr. of 0·86 and is either combined with the light crude oil when ready for distillation or distilled by itself; it gives the products of the light crude oil with higher boiling points. Solar oil I. has a sp. gr. of from 0·875 to 0·885 and is split up by distillation into light colored paraffine oil and oils containing paraffine. The latter are

separated into two fractions according to their paraffine content, which are then separated from the paraffine by cooling. This paraffine is called solar paraffine mass and secondary paraffine mass. The oil coming from the solar paraffine mass is again distilled and chemically treated and gives yellow and red oils which will keep their color and which are known commercially as fatty oils. From the secondary paraffine mass an oil is obtained which on distillation gives paraffine oil (gas oil) and tertiary paraffine mass. From the latter the paraffine is obtained separately.

The press oil is obtained from the process of purifying paraffine with lignite tar oil, and contains the mineral oils present in the paraffine. The paraffine is removed from it by cooling and the oil is then distilled. A product is then obtained which is similar to the crude photogen or the crude photogen II., and which is treated like these oils. In all these distillations the work is done according to the conditions of the market and the requirements in regard to the smell and color of the oils. The most valuable product of the mineral-oil industry of Saxony-Thuringia is without doubt the paraffine, and care must be taken to extract this from the oils as much as is possible.

The "Mixing Process."—This treats the tar and its products with chemicals. It is done in Saxony-Thuringia in cylindrical vessels with conical bottoms, whose size varies between 2 and 20 cu. m. The apparatus is made of wood or iron and is generally lined on the inside with lead. For mixing the oils with the chemicals use is made either of (1) an ascending and descending perforated piston (Huebner); (2) of centrifugal force (Voigt); (3) of a paddle wheel (Perutz); (4) of a wind shaft attached to the bottom (Jacobi), or (5) of air which is blown in by means of an air pump through a pipe reaching to the bottom of the mixing vessel. The last mentioned process is the best. In a large mixing house there are 10 mixing vessels; the chemicals used, sulphuric acid and caustic soda, are forced from a pressure chamber in the loft into a measuring vessel at a high level, and from thence they are run to the mixing vessels, where they are poured upon the contents through a sieve, and then mixed by air.

The lignite tar products are generally mixed first with sulphuric acid at 66° B. and then with caustic soda lye. The sulphuric acid doubtless dissolves the basic substances, the olefines in part and in the case of the tar takes up undecomposed bitumen. At the same time a polymerization of the hydrocarbons and partial oxidation must be assumed. A sufficiency of sulphuric acid is recognized by the color of the tar product and by the scum which is produced. Generally the liquids are brought together while cold, with the exception of the oils which contain paraffine which require to be heated. The amount of the chemicals and the duration of the mixing process are matters of experience; generally a half-hour mixing with from 2 to 10% of sulphuric acid is sufficient. After the tar product has rested for two hours the sulphuric acid laden with tar oils—the so-called acid resins—is drawn off. The soda lye takes from the tar products the acids and indifferent bodies which are soluble in creosote-soda, but which are again separated on dilution with water. Only distillates of the tar and not the tar itself can be treated in this way. From the mixing process which takes about half an hour, creosote-soda is obtained which is drawn off after about three hours.

Factories which make pyridin bases treat light crude oil for one quarter of an hour with a 0·5% of sulphuric acid at 30° B. previously aciduated to remove these substances. The sulphuric solution of the pyridin bases is cleaned by acid resins and oil by letting it settle for some time and filtering it through coke and waste. From 20 to 30% of crude bases are obtained from the total solution by letting it pass into a caustic soda lye. The insoluble bases are deprived of their water and distilled at a temperature of about 270° C. Water is removed from the distillate by means of concentrated soda lye and it is distilled again, whereby it is separated into the fractions desired. The acid resins and the creosote-soda can be brought together directly, whereby creosote and resins are produced in a solution of sodium sulphate. Steam splits up the acid resins into impure sulphuric acid and resins; the creosote-soda is then decomposed by means of the waste sulphuric acid. The resins and creosote are now mixed together. On distilling this mixture, which is done in stills similar to the ones described above, creosote oil is obtained having a sp. gr. of 0·94 to 0·98. As a residue there is left goudron or asphalt. After half of the oil has been obtained paraffine appears, amounting to from 2 to 3% of the oil. If the acid resins are kept separate from the crude photogen and the former is blown away by steam, there is obtained 5 to 10% of the acid resins as acid photogen oil of a sp. gr. from 0·88 to 0·90. It has not been found possible to purify the chemicals used in the mixing process—sulphuric acid and caustic soda—sufficiently for use again; they are, however, turned into a number of by-products, whose sale covers the cost of the chemicals.

In the industry of Saxony-Thuringia the paraffine is obtained in crystalline from the lignite tar. The more developed the crystals are, the more easily can the oil adhering to them be removed and the purer is the paraffine. For crystallizing the hard paraffine masses resulting from the distillation of the tar, cylindrical vessels holding from 50 to 100 l. are used in cool rooms. These vessels have the shape of pails tapering toward the bottom. The soft paraffine masses are generally allowed to crystallize in cylindrical vessels of from 2·5 to 4·5 cu. m. through the action of winter cold,—or of ice machines. In summer the temperature is reduced to 0° and in winter from —3 to —7° C.; the cost of cooling 100 kg. of paraffine amounts to 25 pfennige. Hard paraffine in vessels having a capacity of 50 to 100 l. requires 5 to 10 days to crystallize when the cooling is done in the air. In the cylinders one day is allowed for cooling in the air and three days for cooling in water at 15 to 20° C. When cooling is carried on too far it causes a separation of the fixed hydrocarbons with high boiling points, which color the crude paraffine green, but which remain dissolved in the oil at higher temperatures. Softer paraffine masses are previously cooled with water at from 15 to 20° C. for one to two days and then crystallized by a salt solution at from —4 to —8° C., if they are not left to the cold of winter altogether. At times the oil is separated from the crystallized paraffine mass, but generally the mass is treated without separation of the oil. The contents of the crystallizing vessels are drawn out by a mechanical device and pushed into a mashing apparatus where they are disintegrated and forced by a pump to the filtering press to separate the paraffine crystals from the oil. The paraffine scales remain hanging between the cloths of two filter plates, while the oil flows off. By means of the pump a pressure of two

to three atmospheres is produced, to adjust which an air chamber is placed between the pump and the filter press. Two to three presses are connected by a common compression pipe. After compression the filter plates are separated, and the compressed cakes are smoothed with wooden knives. Each press delivers on an average 75 kg. of filter scales, which still contain 25 to 30% of oil. These scales are pressed a second time in vertical hydraulic presses at 100 to 150 atmospheres after having first been wrapped up in wool and cotton. A press of this kind can work ten times in twelve hours and delivers each time 55 to 66 kg. scales with 10 to 15% of oil. From this compression there is obtained from the hard paraffine mass (A mass) 15 to 25% of hard scales, having a melting point of 50 to 55° C.; from the secondary mass (B mass) 20 to 25% of secondary paraffine scales, having a melting point of 40 to 45° C.; the waste oil is here called paraffine oil; from the solar paraffine mass 20 to 25% of solar paraffine scales, having a melting point of 38 to 42° C., the waste oil being called crude fatty oil or paraffine oil; from the tertiary paraffine mass (C mass) 10 to 15% tertiary paraffine scales whose melting point is 30 to 35° C.

Another process for removing the oil from the paraffine consists in melting the paraffine scales by means of steam and mixing them with 10 to 20% of benzine, light lignite tar oil, and then pouring thereon water. The paraffine solidifies to a cake which is cut into pieces and pressed in horizontal hydraulic presses at 200 to 240 atmospheres. This press works ten times in 12 hours, and each time changes 90 kg. of paraffine cake into 70 kg. of compressed paraffine; the press oil, which is very rich in paraffine, runs off in troughs. The pressed plates are again melted, mixed with benzine and pressed for a second time.

The purified paraffine no longer contains any heavy oils and the smell of benzine must be removed. It is placed in stills similar to the distilling stills. The benzine is removed by turning on steam. This is the "blowing off" of the paraffine. The benzine vapors are condensed in coolers. The paraffine during the process is at a temperature of 130°C., and the highest should not be over 140°C. To remove the greenish yellow color from the paraffine, which has been rendered odorless, it is treated with a decoloring agent. The paraffine is mixed in vessels heated by steam (70 to 80° C.) with the cheap blood lye salt residues, which have been previously dried at a temperature of from 100 to 110° C. The mixing with 1 to 2% of the decoloring powder is accomplished by a stirring apparatus and takes about half an hour. The decolorization is a purely mechanical process and is based on surface adhesion. The powder is allowed to settle and the paraffine resting over it is filtered through paper filters or through filter presses heated by steam. The decoloring powder contains much paraffine after using which must be regained. For this purpose it is treated with light lignite tar oil, and the paraffine is obtained from the extract by cooling and pressing or by evaporation of the solvent.

The market products of the industry of Saxony-Thuringia are:

Oils. 1. The light lignite tar oil, the benzine, is used in refining the paraffine, and is sold under the name of photogen; it is used as a lighting oil in the photogen, camphine and mineral oil lamps. 2. The solar oil or "German petroleum" is used as a lighting oil, either alone or mixed with the fine petroleum,

but it requires more air to burn than petroleum, as it contains more carbon in proportion to hydrogen. Special solar oil burners are therefore used. During the last years solar oil has been used for driving motors and in the manufacture of soot. 3. The light colored paraffine oils (polishing oil, yellow oil, red oil) are used in the manufacture of quinine, or as gas oils, or are used in the manufacture of fine wagon grease. 4. Gas oil or dark paraffine oil is used for the manufacture of oil gas and wagon grease. It also makes an excellent fuel. 5. The crude fatty oil is reddish brown. Wagon grease is made from it, and it is used as an addition to lubricating oils. 6. The refined fatty oil is used similarly to 5. 7. The heavy paraffine oil is used as a fuel and for the manufacture of wagon grease. It is also added to the feed water to prevent boiler incrustations. 8. The creosote oil is used in the manufacture of soot and to impregnate wood.

Creosote Soda and Creosote.—1. Creosote soda contains about 50% of creosote. It is used to impregnate mine trucks, and can also be used as a disinfectant. 2. Creosote is a popular disinfectant, which is still further refined in special factories.

Asphalt and Goudron.—1. The asphalt is added to the natural asphalt; the best quality is soluble in oil of turpentine and is used in the manufacture of varnish. 2. The mineral goudron is added to the raw products in the manufacture of asphalt pavements and wood-cement, also for purposes of insulation in buildings.

Nitrogen Bases.—Pure tar acids have not been produced as yet. On the other hand, refined nitrogen bases (pyridin bases) have been used to denaturize spirit. It is also used for refining anthracene.

Paraffine.—The hard, firm crystalline masses reach the market in pieces of definite shape of 1 kg. weight—the softer varieties in tablets, and the softest stamped into barrels. The paraffine is used mostly for candle molding; besides, it is used to impregnate sponges and paper, as a finishing substance for leather and textile fabrics, as a protective covering against acids and alkalies and easily oxidizable substances; it is also used in the manufacture of sugar, in toy factories and in glass factories for feeding lamps, and as a non-conductor in electrical work.

This long series of products obtained from the lignite tar accounts for the continued development of the mineral-oil industry of Saxony-Thuringia under unfavorable conditions, which are chiefly due to American competition.

PRODUCTION OF THE TAR DISTILLERIES AND MINERAL OIL FACTORIES OF THE PROVINCE OF SAXONY.

	1895.	1896.	1897.	1898.	1899.
Distilled coal, in hectoliters	13,982,030	13,988,858	13,510,759	13,988,644	15,107,384
Coal used in distilling, in hectoliters	6,078,734	5,704,288	5,436,745	5,577,181	6,176,442
Production of tar, in kilograms	62,962,339	62,434,195	58,443,061	59,844,944	63,618,490
Tar products, in kilograms	63,070,173	62,398,230	59,230,962	61,236,955	63,246,005
Coal burned in distilling the tar, in hectoliters	3,300,633	3,394,198	3,290,948	3,244,886	3,270,841
Number of distilling ovens	1,222	1,220	1,194	1,186	1,327
Number of workmen in the distilling establishments	1,035	1,021	1,010	1,015	1,125
Number of workmen in the mineral oil and paraffine factories	1,377	1,397	1,353	1,349	1,328

Condition of the Mineral Oil Factories and Paraffine Markets during 1898 and 1899.—Mineral oils and by-products in 1898 were largely in demand;

as a result the stock of the gas oils and polishing oils, of fatty and other heavy oils and the supply of solar oil was reduced to such an extent that prices advanced sharply. The trade in paraffine was even less satisfactory than in the preceding year, as on account of American competition no business could be done in other countries, or, if done, it was only with very little profit. The importation of foreign products into Germany caused a further decline in the price of Saxon paraffines. The competition with the American paraffines continued until the early part of 1899 and then ended in favor of the Saxony-Thuringian oil industry. At the most favorable period the prices for paraffine improved almost 30 marks per 100 kg.

Only a few firms are worthy of mention in the production of the mineral and paraffine industry of Saxony during 1898 and 1899; the production for the latter year is included in brackets. The Risbeck Works distilled 24,783 (26,141) metric tons of lignite tar and obtained 1,468 (1,397) light oils and solar oil, 2,096 (2,098) of polishing oil and light colored paraffine oils, 9,196 (11,070) of dark paraffine oils, 480 (109) of fatty oils of all kinds, 1,148 (1,108) of creosote oil, 389 (397) of creosote and creosote-soda, 1,158 (1,732) of mineral goudron, 867 (642) of lignite pitch, 484 (522) of miscellaneous products and 3,301 (3,642) of paraffine of all kinds.

The Saxony-Thuringian Co., for the utilization of lignite, obtained 9,473 (9,625) metric tons of lignite tar, and from this made 794,798 kg. paraffine, 1,144,293 kg. paraffine candles, 1,157,463 kg. solar oil, 1,190,046 kg. yellow paraffine oil, 3,076,325 kg. dark and red paraffine oil, 18,323 kg. fatty oil, 496,370 kg. creosote oil, 88,013 kg. paraffine grease, 125,210 kg. goudron, and 96,591 kg. asphalt. In 1899 there were prepared from tar 8,376,489 kg. of by products.

The Lignite Co. of Werschen-Weissenfels obtained 5,292,700 (6,553,150) kg. of tar and made 4,473,535 (5,312,825) kg. mineral oils and by-products. The Zeitzer Paraffine and Solar Oil Factory worked 8,986,156 (8,786,473) kg. tar. The Lignite-Industry Co. of Doerstewitz-Rattmannsdorf obtained from 113,921 (97,382) hl. of coal, 531,226 (430,295) kg. tar, bought 1,592,301 (1,893,925) kg. of tar besides and obtained 221,782 (188,762) kg. photogen and solar oil, 359,256 (350,148) kg. hard and soft paraffine, 1,043,180 (998,380) kg. yellow, red and dark paraffine oils and 256,935 (240,693) kg. residual products. The Lignite Co. of Waldau treated 4,227 (4,045) metric tons tar, and the factory of Hugo Carlson distilled 542,040 hl. coal to 1,568 metric tons of tar, which were there further treated. The production during 1899 was satisfactory.

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COPPER.

THE production of copper in the United States showed a moderate increase in 1900, the total being 600,832,505 lb. as compared with 581,319,091 lb. in 1899. There was an unexpected falling off in the output of Michigan, and the Arizona mines, with but few exceptions, failed to maintain the productive rate of the previous year. On the other hand, Montana continued to advance and the output for the year as reported by the mining companies exceeds by nearly 17,000,000 lb. the record figures of 1899. Among the other copper producing States, California and Utah were the most prominent, the former contributing to the total nearly 30,000,000 lb. and the latter over 18,000,000 lb. The output of Colorado was less than for several years past.

The reports of the American copper refiners show a total production for 1900 of 466,092,663 lb. electrolytic copper as against 386,410,356 lb. in 1899. The production of copper sulphate was 78,218,478 lb. compared with 67,903,370 lb.

COPPER PRODUCTION IN THE UNITED STATES. (LB. OF FINE COPPER.)

States.	1897.		1898.		1899.		1900.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	81,019,922	36,170	110,823,864	49,475	125,377,758	55,972	115,403,846	51,520
California	14,129,920	6,308	21,543,229	9,618	23,915,486	10,677	29,639,987	13,232
Colorado	9,437,663	4,213	10,870,869	4,853	10,614,252	4,739	7,826,949	3,494
Michigan	145,839,749	65,107	156,669,098	69,951	155,845,786	69,574	144,227,340	64,387
Montana	237,158,540	105,874	216,979,334	96,866	237,953,951	106,229	254,460,713	113,599
Utah	3,854,821	1,721	5,385,246	2,404	9,310,344	4,156	18,504,726	8,261
Eastern and Southern States	3,727,939	1,664	4,478,218	1,999	3,804,617	1,698	6,918,122	3,088
All others	2,018,929	901	2,134,999	953	4,989.000	2,227	12,536,850	5,597
Copper in sulphate (*b*)	4,182,812	1,867	7,015,375	3,132	9,507,897	4,245	11,313,962	5,051
Total domestic production	501,370,295	223,825	535,900,232	239,241	581,319,091	259,517	600,832,505	268,229
Stock January 1	83,600,000	37,321	48,882,143	21,821	54,361,470	24,269	88,722,559	39,608
Imports bars, ingots, old, and ores	*a*26,988,254	12,026	43,479,282	19,410	94,568,050	42,218	103,805,793	46,342
Total supply	611,908,549	273,172	628,261,663	280,474	730,248,611	326,004	793,360,857	354,179
Deduct exports	288,626,240	128,851	299,765,054	*c*133,824	249,923,941	*c*111,573	352,731,143	157,469
Deduct consumption	274,400,166	122,500	274,135,139	122,382	391,602,111	174,822	347,579,484	155,169
Stock December 31	48,882,143	21,821	54,361,470	24,269	88,722,559	39,608	93,050,230	41,541

(*a*) This includes copper imported in low-grade Spanish and other pyrites chiefly for sulphur, and the copper imported from Canada in copper-nickel matte, in which the nickel is the metal of chief value; also the copper in certain gold and silver ores. These items did not until 1898 appear in the United States statistics of imports. (*b*) Including only the copper in sulphate obtained as a by-product in 1897 and 1898. (*c*) Not including Mexican copper en route for Europe.

in 1899, while the average price for 1900 was 4·99c. per lb. as compared with 5·2c. for the previous year. Of the total production of copper sulphate in 1900 the amount recovered as a by-product was 44,368,478 lb.

The stock of copper on hand at the end of 1900 was 93,050,230 lb., as against 88,722,559 lb. at the beginning of the year. These figures include copper in the course of treatment at electrolytic works, but not the mineral carried at Buffalo by the Calumet & Hecla company nor the stock at railway depots and in second hands. The imports as reported by the smelting and refining companies and by the United States Treasury Department were 103,805,793 lb., against 94,568,050 lb. in 1899, while the exports amounted to 352,731,143 lb., the largest in the history of the industry and more than 100,000,000 lb. in excess of the exportation in 1899. The unprecedented foreign demand gave strength to the market, and prices averaged 16·52c. for Lake copper compared with 17·61c. in 1899, notwithstanding the fact that there was a marked decline in domestic consumption.

Arizona.—The production of the individual mines in this Territory during 1900 and preceding years is given in the following table:

COPPER PRODUCTION IN ARIZONA. (POUNDS OF FINE COPPER.)

Mines.	1895.	1896.	1897.	1898.	1899.	1900.
Arizona Cop. Co..	11,308,910	13,042,000	13,727,911	18,169,096	19,072,709	19,697,086
Copper Queen...	15,741,731	23,298,150	23,999,873	33,749,390	36,901,684	34,382,309
Commercial.....	*Nil.*	46,040	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Detroit.....	3,790,128	7,016,348	8,405,138	11,428,992	13,906,253	10,749,258
Old Dominion....	*Nil.*	5,650,000	2,000,000	1,800,000	6,300,000	7,155,000
United Verde....	16,491,402	22,327,950	31,355,025	42,328,926	43,995,932	39,970,193
United Globe....	*Nil.*	2,020,565	1,241,975	2,847,460	4,451,180	*Nil.*
Other mines.....	997,232	344,268	290,000	*e* 500,000	*e* 750,000	*e* 3,450,000
Totals.....	48,329,403	73,745,321	81,019,922	110,823,864	125,377,758	115,403,846

(*e*) Estimated.

(By James Douglas.)—The predictions made last year of an increase of Arizona's production have not been fulfilled. The coal strikes of Colorado interfered seriously with the supply of fuel, and the burning down of the smelting works of the Detroit Copper Co. in June cut off the supply from that source for several months. None of the mines exhibits symptoms of impoverishment or exhaustion, the decrease being due solely to accidental causes. The production in 1900 was 115,403,846 lb., against 125,377,758 in 1899, a decrease of 9,973,912 lb. The United Verde Co. has improved its plant without notably increasing it, but its metallurgical operations have been seriously interfered with by the coal miners' strike, which for many months completely shut off supplies from the Galloupe district. At the Copper Queen a fifth furnace and another stand of converters have been erected. The effect has been less to increase the production of the company than to enable it to convert all its product into Bessemer bars. A new shaft has been sunk and equipped with steel gallows-frame and a large hoist. This increase in plant has also been made, not so much with a view of increasing production, as of enabling more active development and dead work to be carried on underground, the older shafts and equipment having been strained to their utmost to hoist ore alone. The confined situation in which the metallurgical works at the Copper Queen are built seriously interferes with the intro-

duction of improvements as well as extensions, and therefore there is no probability of largely increased production during 1901.

Three other companies, the South Bisbee, the Lowell & Arizona, and the Bisbee & Lake Superior are actively at work in the Warren district. Their operations have been conducted with both skill and energy, and with honest purpose, and all three have met with considerable encouragement, though no one of them as yet is, or is likely to be during 1901, a large producer. Globe has produced more during 1900 than for many years previously. The Old Dominion Co.'s smelter has run steadily, making above 750,000 lb. monthly, and the United Globe mines have shipped ore to the El Paso smelter, which continues to be the only notable source of bar copper made directly from the ore. But the losses in slag are such that, if acceptable rates could be obtained, sulphide ores would be imported from Bisbee and the Globe ores matted. Unfortunately, as yet the scale of railroad charges in Arizona prohibits that interchange of ores from district to district which would greatly help Arizona's mining and metallurgical interests. At Clifton the smelting and leaching works of the Arizona Copper Co. have been run to their utmost capacity, and their production has been the largest on record. It is remodeling its smelting works, which may interfere somewhat with the production for 1901, but will enable the company in future to make better use of its large mineral reserves. According to its report for the fiscal year ending September 30, 1900, $2,929,618 was realized from sales of pig and ingot copper, while the mining, smelting and selling expenses were $1,737,358. The Detroit Copper Co., as already remarked, suffered from a fire which burned not only its smelting works but one of its concentrators. The smelting works have been rebuilt, but the old concentrator which was destroyed at the same time will not be replaced. The new 400-ton concentrator was fortunately completed before the fire, and will enable the company to increase their production during 1901. The novel feature at both the Arizona Copper Co.'s and the Detroit Copper Mining Co.'s works is the large use at both places of gas engines. At both works the most satisfactory type of engine as yet employed is the Crossley "Otto." At the Arizona Copper Co.'s works the gas is made exclusively in Dowson producers from hard coal. But at Morenci, the Detroit Copper Co. has a Loomis generator capable of making gas for 1,000 H.P. from soft coal. The fuel economy is unquestionable, ranging from 1·5 to 1·75 lb. per horse-power hour, and the delays and interruption which were at first incidental to the introduction of such a novelty are being rapidly eliminated. Making allowances for unforeseen contingencies, there is no reason to suppose that Arizona's production for 1901 will exceed her production for 1899. Of the many new companies, none as yet has developed into an actually large producer, while some have already become moribund. Whatever may be the future of the most promising of these mines none of them will disturb the market during the year 1901 by its voluminous output.

California.—The greater part of the output of copper in California continues to be produced by the Mountain Copper Co., Ltd., at Keswick, where, during 1900, 207,571 tons of ore were smelted, yielding 11,978 tons of copper which were shipped to its works at Elizabethport, N. J., to be refined. Out of the total net profits for the year of £300,270, a dividend of £112,500 or 9s. per share was

paid and £100,000 added to the reserve and depreciation fund, leaving a balance of £87,771 on the year's operations, or £93,010 in all. An additional dividend of £87,500 was proposed, making the year's distribution at the rate of 16% on the 250,000 shares. The company has accomplished considerable development work at the Keswick mines and a copper converting plant of three stands of converters will be erected early in 1901. An interesting feature of the industry is the use of crude oil as a metallurgical fuel for the boiler and Ropp roasting furnaces. Extensive mines are being developed in Shasta County under the control of Captain De Lamar, and in Calaveras County the Williams Bros. are opening up the old Napoleon mine near Copperopolis. Other copper deposits in the southern part of the State are being developed by Boston capital and smelting works are in course of erection at Raymond, Madera County. The principal smelting works are the Keswick smelter of the Mountain Copper Co., Ltd., which ships its product East to be refined and the plant of the Selby Smelting & Lead Co., at Vallejo, which produces metallic sulphate but no refined copper. The Needles Smelting Co. erected a smelting plant at Needles, San Bernardino County. The blast furnace is 36×96 in. section at the tuyeres and is of modern construction. This furnace was blown in early in 1901 and produces matte and black copper which is shipped East for refining. A two-compartment sheet-iron condensing chamber is used to collect the flue-dust. Water sprays running over deflecting sheets from overhanging perforated pipes, wash the furnace gases that pass through the chamber. This arrangement is reported to be very effective. The smelting charges of this company per ton for copper ores are as follows: Under 5% Cu, $8; from 5 to 10% Cu, $7; 10 to 15% Cu, $6; $15 to 20% Cu, $5·50; 20 to 25% Cu, $5; 25 to 30% Cu, $4·50. These treatment charges are for dry copper content; when assayed by wet methods 1·5% Cu is to be deducted. Payment is made for 95% of the silver at New York quotation on the date of release. Payment for gold from 0·1 to 3 oz. inclusive, $19 per oz., above 3 oz., $19·50 per oz. Neutral basis for silica and iron, $0·15 up or down to a maximum of $12·50 per ton. The limit for zinc is 8%, beyond which $0·50 per additional unit is charged. The sulphur limit is 5% and $0·25 per unit is charged for excess. The Copper King Co., Ltd., with mines in Fresno County, has erected a smelter for the treatment of its own and custom ores at Seal Bluff Landing, Cal. The Trinity Copper Co., with a capital of $6,000,000 in $25 shares, has been incorporated in New Jersey to operate properties in Shasta County, on which it holds options.

Colorado.—The production in 1900, as reported by the Hon. Harry A. Lee, Commissioner of Mines, was 7,826,949 lb., against 10,614,252 lb. in 1899. The mines in Lake and San Juan counties contributed the greater part of the output. The value of the copper produced in the Leadville district in 1900 was $450,757, against $1,137,577 in 1899, showing a marked decrease during the past year. Several new smelters have been erected, which are referred to elsewhere in this section.

Michigan.—The production of copper from the individual mines during 1900 and preceding years is given in the table on the following page.

COPPER PRODUCTION IN MICHIGAN. (POUNDS OF FINE COPPER.)

Mines.	1895.	1896.	1897.	1898.	1899.	1900.
Arcadian	*Nil.*	*Nil.*	*Nil.*	*Nil.*	500,000	*e* 800,000
Atlantic	4,832,497	4,894,228	5,109,663	4,377,399	4,675,882	4,930,149
Baltic	*Nil.*	*Nil.*	*Nil.*	42,766	603,570	1,735,060
Calumet & Hecla	77,439,907	90,356,733	88,378,986	94,103,000	98,002,137	81,403,041
Central	370,381	469,243	611,172	291,339	*Nil.*	*Nil.*
Franklin	3,086,933	2,746,076	2,908,384	3,568,978	1,230,000	3,668,710
Kearsarge	1,946,163	1,337,226	(*a*)	(*a*)	(*a*)	(*a*)
Mass	18,372	38,684	24,081	*Nil.*	61,000	*Nil.*
National	50,128	53,762	28,959	18,441	*Nil.*	*Nil.*
Osceola Consol'd	6,270,373	6,251,304	9,500,000	11,800,000	10,950,000	11,200,000
Quincy	16,304,721	16,863,477	16,924,618	16,354,061	14,301,182	14,116,551
Ridge	64,363	*Nil.*	12,590		(*b*)	(*b*)
Tamarack	14,840,000	16,495,000	20,000,000	22,500,000	17,750,000	18,400,000
Tamarack Junior	2,605,000	2,330,000	(*a*)	(*a*)	(*a*)	(*a*)
Wolverine	1,817,806	2,195,791	2,316,296	4,588,114	4,789,015	4,778,829
All other mines	94,121	27,000	25,000	*e* 25,000	2,983,000	3,200,000
Totals	129,740,765	144,058,524	145,839,749	156,669,098	155,845,786	144,227,340

(*a*) Consolidated with the Osceola. (*b*) Consolidated with Mass. (*e*) Estimated.

The output of copper in 1900 was less than in the previous year, owing to the decrease in the Calumet & Hecla production. The new mines did not add materially to the total, nearly all being still in the development stage, but they may be expected to assume considerable importance before the close of 1901. During the past year the copper mines distributed $9,798,000 in dividends.

The subjoined table and those on the opposite page show the results obtained by the principal mines, their capitalization, profits and itemized costs of production for the period 1892-1900. These tables are a continuation of the statistics given in THE MINERAL INDUSTRY, Vol. I., to which reference may be made for previous years.

CALUMET & HECLA MINING CO.

Year.	Capital Paid In.	Real Estate. Amount Invested.	Personal Estate. Amount Invested.	Debts.	Credits.	Copper Produced Lbs.	Yield. (*b*) %	Average Price per lb. (*a*)	Estimated Receipts.	Dividends.
1892	$1,200,000	$5,718,369	$5,255,080	$1,252,956	$4,045,277	58,292,576	3·40	11·67c.	$6,802,744	$2,000,000
1893	1,200,000	6,096,484	5,731,900	689,572	4,185,729	62,825,674		10·91	6,854,281	2,000,000
1894	1,200,000	6,354,690	6,054,216	812,124	5,464,671	61,842,722		9·63	5,955,454	1,500,000
1895	1,200,000	7,000,578	6,200,397	1,295,377	7,204,231	77,439,907		10·66	8,254,494	2,000,000
1896	1,200,000	7,169,786	6,392,083	1,301,215	8,866,542	90,356,733	3·09	10·98	9,921,169	2,500,000
1897	1,200,000	13,596,348	6,265,426	1,275,599	3,668,150	88,378,986		11·12	9,827,743	5,000,000
1898	1,200,000	14,223,895	4,134,321	2,235,543	6,280,589	94,103,000	3·07	12·01	11,301,770	5,000,000
1899	1,200,000	14,032,991	7,215,716	2,298,467	1,669,622	98,002,137		16·92	15,788,162	10,000,000

(*a*) Prices obtained by taking the average prices realized by the other leading mines, including Quincy, Tamarack, Atlantic and Wolverine. (*b*) Computed from the shipments of freight over the Hecla and Torch Lake Railroad. On this basis the yield in 1891 was 3·13% and in 1875, 4·30%.

The Calumet & Hecla Mining Co. continued development work on the Osceola amygdaloid, but closed down three of the five shafts in the latter part of the year. A new mill, supplied with six steam stamps is being built to treat this ore, but will not be in commission for some time. With five large shafts bottomed in the amygdaloid, the company is in position to exploit this mine very rapidly and doubtless will do so as soon as adequate facilities for handling the ore are provided. The smelting works at Lake Linden were enlarged, three of the reverberatory furnaces being altered to treat the low-grade ore, and new stacks and a cupola added. Each of the reverberatory furnaces is equipped with a steel charging platform which reduces hand labor to a minimum. The mine suffered considerable loss by fire which broke out in Hecla shaft No. 3 in the latter part of

ATLANTIC MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Cost of Ton of Ore Stamped.						Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit.	
							Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage			Per Pound.	Per Ton, Milled.
	$	Tons.	Lbs.	%	Cts.	$	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$	Cts.	$
1892	980,000	300,900	3,703,875	0·615	11·90	444,124·39	64·93	3·33	19·04	25·09	3·44	17·67	10·89	1·34	1·01	0·12
1893	980,000	315,670	4,221,933	0·669	10·63	455,500·30	62·27	3·28	17·22	24·95	34·30	18·22	12·00	1·60	—1·37	—0·18
1894	980,000	315,626	4,437,609	0·703	9·51	425,066·90	58·66	3·03	16·52	23·30	45·85	17·71	11·74	1·65	—2·23	—0·31
1895	980,000	331,058	4,832,497	0·73	10·52	509,012·74	57·09	4·08	18·16	22·20	35·71	18·81	10·79	1·56	—0·29	—0·025
1896	980,000	371,128	4,894,228	0·66	10·84	531,160·85	58·45	4·96	17·98	24·87	12·26	17·47	10·30	1·36	0·54	0·07
1897	980,000	394,296	5,109,663	0·65	11·23	574,783·65	56·30	4·54	17·13	23·94	10·75	17·03	10·01	1·30	1·22	0·16
1898	980,000	370,767	4,377,399	0·59	11·83	518,219·14	66·77	5·55	22·34	24·11	19·18	16·04	13·01	1·54	—1·18	—0·14
1899	980,000	380,781	4,675,882	0·614	17·15	802,804·51	78·58	6·50	25·02	23·35	20·62	17·04	13·93	1·71	3·22	0·40
1900	980,000	410,674	4,930,149	0·600	16·41	809,177·00	76·85	6·92	26·73	24·70	27·75	14·70	14·80	1·78	1·61	0·19

FRANKLIN MINE.

						(*a*)	(*b*)									
1892	2,000,000	123,236	3,769,605	1·53	11·75	446,594 02	2·39	(*d*)	(*d*)	(*d*)	(*d*)	43·80	9·24	2·83	2·76	0·77
1893	2,000,000	124,890	3,504,244	1·40	9·91	352,667·78	2·01	(*d*)	(*d*)	(*d*)	35·25	38·62	9·78	2·74	0·13	0·04
1894	2,000,000	138,163	3,556,487	1·29	9·71	347,262·19	1·92	(*d*)	(*d*)	(*d*)	17·04	32·05	9·35	2·41	0·36	0·09
1895	2,000,000	126,990	3,086,933	1·22	10·71	333,363·51	1·96	(*d*)	(*d*)	(*d*)	7·82	34·74	9·80	2·39	0·91	0·22
1896	2,000,000	122,079	2,746,076	1·12	11·19	307,447·99	2·02	(*d*)	(*d*)	(*d*)	(*d*)	32·68	10·44	2·85	0·75	0·17
1897	2,000,000	132,026	2,908,384	1·10	11·05	320,917·33	2·03	(*d*)	(*d*)	54·00	(*d*)	32·71	10·71	2·36	0·34	0·07
1898	2,000,000	116,696	2,623,702	1·12	12·07	317,917·63	1·77	(*d*)	(*d*)	51·02	(*d*)	34·29	9·39	2·11	2·68	0·61
1899	2,000,000	89,789	1,230,000	0·68	16·48	202,647·81	(*d*)	(*d*)	(*d*)	32·30	(*d*)	32·28	(*d*)	(*d*)	(*d*)	(*d*)
1900	2,000,000	268,571	3,663,710	0·68	16·20	594,252·36	1·72	(*d*)	(*d*)	36·34	0·04	23·79	17·90	2·41	1·70	0·27

OSCEOLA MINE.

1892	1,250,000	247,575	7,098,656	1·43	11·68	835,471·20	1·35	15·45	18·07	37·85	10·89	44·15	9·12	2·61	2·56	0·74
1893	1,250,000	236,875	6,715,870	1·42	10·95	739,135·40	1·37	15·46	17·90	34·92	18·99	43·73	9·48	2·68	1·47	0·42
1894	1,250,000	264,050	6,918,502	1·31	(*d*)	661,534·08	(*c*)1·50	(*d*)	(*d*)	29·40	6·81	41·92	8·70	2·28	0·86	0·23
1895	1,250,000	233,969	6,270,373	1·34	(*d*)	669,907·33	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	8·75	2 34	1·94	0·52
1896	1,250,000	248,062	6,251,304	1·26	(*d*)	687,017·85	(*d*)	(*d*)	(*d*)	24·79	25·40	(*d*)	9·64	2·43	1·35	0·34
1897	2,275,000	443,080	9,500,000	1·072	(*d*)	1,338,056·11	(*d*)	(*d*)	(*d*)	25·57	17·64	(*d*)	11·32	2·43	2·76	0·59
1898	2,325,000	505,008	11,800,000	1·168	(*d*)	1,549,820·12	(*d*)	(*d*)	(*d*)	28·94	18·10	(*d*)	9·98	2·33	3·15	0·74
1899	2,328,750	546,326	10,950,000	1·002	(*d*)	1,791,471·01	(*d*)	(*d*)	(*d*)	26·30	13·29	(*d*)	11·48	2·30	4·92	0·98
1900	2,397,500	683,066	11,200,000	0.819	(*d*)	2,136,253·02	(*d*)	(*d*)	(*d*)	27·20	27·68	(*d*)	13·92	2.28	5·15	0·85

QUINCY MINE.

						(*e*)	(*f*)								(*i*)	(*i*)
1892	200,000	323,051	11,103,926	1·72	11·27	1,253,158·23	1·82	(*d*)	(*d*)	(*d*)	67·74	51·60	8·77	2·98	2·50	0·90
1893	200,000	422,239	14,398,477	1·71	10·48	1,511,039·06	1·75	(*d*)	(*d*)	(*d*)	17·75	47·92	7·05	2·41	3·43	1·17
1894	200,000	454,783	15,484,014	1·70	9·48	1,470,272·46	1·52	(*d*)	(*d*)	(*d*)	0·39	41·09	5·69	1·94	3·81	1·29
1895	200,000	495,402	16,304,721	1·65	10·17	1,661,446·58	1·54	(*d*)	(*d*)	(*d*)	(*d*)	41·63	5·95	1·96	4·24	1·40
1896	200,000	555,543	16,863,477	1·52	10·92	1,864,197·61	1·61	(*d*)	(*d*)	(*d*)	(*d*)	38·68	6·58	2·00	4·47	1·36
1897	1,450,000	542,623	16,924,618	1·56	11·07	1,890,238·64	1·73	(*d*)	(*d*)	(*d*)	34·03	39·53	6·91	2·16	4·27	1·33
1898	1,450,000	543,592	16,354,061	1·54	12·14	1,986,116·81	1·65	(*d*)	(*d*)	(*h*)22·28	39·59	34·23	8·17	2·39	3·97	1·16
1899	1,450,000	559,164	14,301,182	1·27	17·13	2,450,178·66	1·81	(*d*)	(*d*)	(*h*)22·19	72·39	27·50	10·96	2·81	6·17	1·58
1900	1,450,000	558,723	14,116,551	1·26	16·67	2,353,416·59	2·08	(*d*)	(*d*)	(*d*)	108·3	28·17	13·63	3·44	3·04	0·77

TAMARACK MINE.

(*g*)1892	1,250,000	338,700	16,805,360	2·48	11·35	1,920,694·32	1·75	16·40	26·75	32·99	50·21	77·90	7·64	3·79	3·71	1·84
(*g*)1893	1,250,000	345,925	16,061,106	2·32	11·53	1,857,274·20	1·69	16·40	28·00	32·84	44·21	82·12	8·03	3·73	3·50	1·62
(*g*)1894	1,250,000	(*d*)	15,375,000	(*d*)	9·82	1,515,173·07	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	8·39	(*d*)	1·43	(*d*)
1895	1,250,000	(*d*)	14,840,000	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)
1896	1,500,000	490,625	16,495,000	1·68	10·56	1,746,188·36	(*c*)1·98	(*d*)	(*d*)	29·95	52·33	53·14	9·91	3·33	0·65	0·22
1897	1,500,000	611,539	20,000,000	1·63	11·32	2,267,340·75	(*c*)1·81	(*d*)	(*d*)	26·41	33·51	59·08	9·18	3 00	2·14	0·70
1898	1,500,000	670,832	22,500,000	(*d*)	(*d*)	2,381,388·95	1·79	(*d*)	(*d*)	22·40	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)
1899	1,500,000	631,090	17,750,000	1·40	(*d*)	2,952,098·91	(*d*)	(*d*)	(*d*)	22·73	63·49	(*d*)	12·46	3·50	4·17	1·17
1900	1,500,000	625,422	18,400,000	1·47	(*d*)	3,299,077·26	(*d*)	(*d*)	(*d*)	31·48	(*d*)	(*d*)	11·41	3·36	6·52	1·92

WOLVERINE MINE.

(*g*)						(*a*)										
1893	600,000	(*d*)	218,855		10·98	54,030·00	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)
1894	600,000	76,440	1,611,857	1·05	9·83	158,507·70	1·08	(*d*)	12·01	35·56	*Nil.*	33·62	8·96	1·89	0·87	0·18
1895	600,000	90,195	1,744,070	0·97	9·68	169,023·86	0·92	(*d*)	15·64	26·99	62·90	23·58	8·45	1·62	1·24	0·24
1896	600,000	85,155	2,011,638	1·18	10·86	219,187·19	1·19	(*d*)	18·87	29·35	*Nil.*	29·97	8·36	1·98	2·50	0·59
1897	600,000	82,270	2,237,698	1·36	11·12	252,088·37	1·38	(*d*)	23·15	29·19	5·52	33·98	8·47	2·30	2·65	0·73
1898	600,000	130,089	3,470,927	1·33	11·43	399,368·77	1·19	(*d*)	23·51	36·63	47·42	33·33	9·73	2·60	1·70	0·45
1899	600,000	184,799	4,700,373	1·27	14·35	675,859·08	1·00	(*d*)	19·66	36·68	5·83	34·00	7·71	1·96	6·64	1·69
1900	600,000	184,594	4,756,646	1·23	16·86	806,810·32	1·12	(*d*)	24·01	41·19	36·67	32·34	9·67	2·46	7·20	1·85

(*a*) Sales of copper and interest. (*b*) Includes underground and surface expenses and costs of stamping. (*c*) Includes transportation to mill and surface expenses. (*d*) Not stated in the reports. (*e*) Not including interest. (*f*) Includes mining, transportation to mill, surface and stamping costs. (*g*) Fiscal year ending June 30 (*h*) Included under mining costs. (*i*) Exclusive of interest and income from real estate.

May, 1900. Work was continued without interruption in the other parts of the mine and the fire was extinguished within a few weeks, but not until serious damage was done. At the Tamarack mine, No. 5 shaft, which was started in August, 1895, struck the Calumet & Hecla conglomerate on December 20, 1900, at a depth of 4,662 ft. The ore is said to be satisfactory and there is no evidence at this depth of the lode flattening out into a basin. The total cost of the shaft, including equipment up to December 31, 1900, was $663,508·60. The Osceola Consolidated Mining Co. nearly completed construction on a new mill which is to have four stamp heads and will double the present stamping capacity. Its South Kearsarge mine is being opened by two shafts and will be a producer in a short time. The Quincy Mining Co. finished its new mill and started two of the three stamps. A large amount of underground development and surface construction was done and the mine will probably increase its production in 1901. At the old mill, the finishing jigs have been replaced by Wilfley tables, and three have been installed also in the new mill. The Baltic Mining Co. largely increased its output of copper, and made fair progress in opening its mine and erecting the necessary equipment. The construction of a stamp mill on Lake Superior is now under way. It is planned for the reception of four heads of stamps, two of which having a capacity of 500 tons each in 24 hours, will be installed at the start, and the others will be added as required. According to the returns for the past year the average yield of copper per ton of rock treated was 19·58 lb., against an average of 17 lb. for the six months stamping in 1899. It is expected that a further increase will be shown during the current year. The report of the directors gives the following items relative to the business of the company during 1900: Copper produced, 1,735,060 lb., which sold for $286,046·85; interest received, $4,488·10; received from Atlantic Mining Co. on account of advances to build railroad to mine, $6,644·87; total receipts, $297,179·82. The running expenses at mine were $256,791·06; costs of smelting, freight and marketing copper, $25,326·85; total running expenses, $282,117·91; surplus, $15,061·91. There was expended also in construction of buildings, machinery, etc., $241,817·89, which was paid out of the surplus from 1899 and 1900, leaving a net balance on hand at the close of the year of $13,838·80. The Arnold Mining Co., a combination of the old Arnold mine and the old Copper Falls mine, continued working both properties. The company owns a tract of 3,323 acres fronting on Lake Superior and surrounded by the Eagle Harbor, Dana, Central, Winthrop and Humboldt mines. It is operating on the Ashbed, a similar and possibly identical formation to that of the Atlantic mine, which averages not more than 0·8% Cu. The Copper Falls mine was at one time operated at a profit. The Phœnix Consolidated Copper Co., which was organized in the spring of 1899 to operate the old Phœnix, St. Clair and Garden City properties, purchased a part of the old Atlas mine, making its holdings 2,585 acres. Operations in 1900 were confined principally to the St. Clair vein, an ore body 18 to 24 in. in width, carrying 2 to 3% Cu. Much of the old equipment is being used in the present exploitation, but a new stamp mill is in contemplation. The Mohawk Mining Co., one of the new mines, owns a tract of 800 acres in Keweenaw County which is underlaid in part by the Kearsarge lode, now operated by the Wolverine and Kearsarge mines. Three

large shafts are being sunk and the mine will be extensively worked as soon as the new mill on Traverse Bay can be constructed. This mine is notable for the occurrence of the new mineral "mohawkite," which was found in a fissure vein of considerable extent. A shipment of 57 tons of ore was made to Swansea which netted $140 per ton. Further exploration along the vein showed the presence of whitneyite and domeykite in notable quantities. A sample analysis of a 60-ton lot gave the following results: Cu, 60%; Ni and Co, 1·28%; As, 17·50%, and silver 6 oz. per ton. The Centennial Copper Mining Co. extended the exploration of the Kearsarge lode, the three-compartment shaft being sunk to a depth of over 800 ft. and a large amount of drifting done at each level. It is stated that the quality of the rock improves with depth and is similar in character to that found further north in the Wolverine, Kearsarge and Mohawk mines. The ore taken out early in the year more than paid the running expenses. It is proposed to construct a new mill on Torch Lake, and an assessment of $5 per share on the capital stock has been levied. The Adventure Consolidated Copper Co., which comprises the Adventure, Knowlton and Hilton mines, was engaged in exploratory and development work on the Butler and Knowlton lodes. Good stamp rock was opened in both lodes and the company will commence construction on a new mill of three heads early in 1901. An assessment of $3 per share has been levied to provide the necessary funds. Although only recently organized, the Arcadian Copper Co. has pushed development and construction work so rapidly that it is now one of the best equipped mines in the field. The rock which it was intended to mine has not come up to expectations, however, and attention is now directed to the Mesnard epidote which crosses the property. Extensive improvements were made by many other mines in the way of new stamp mills, mine equipment, and transportation. A 40-mile extension of the Copper Range Railroad built to connect the Mass mine with the mill on Keweenaw Bay has opened up a large territory of mining and timber lands. The last annual report of the Mineral Commissioner of Michigan states that in 1900 there were 14,250 men employed in the copper mines, while the fatal accidents in a period of 11 years have averaged 3·26 per 1,000.

Montana.—The production of the individual mines in this State during 1900 and preceding years is given in the subjoined table:

COPPER PRODUCTION IN MONTANA. (POUNDS OF FINE COPPER.)

Mines.	1894.	1895.	1896.	1897.	1898.(*d*)	1899.	1900.
Anaconda	95,578,000	99,775,294	125,350,693	131,471,127	107,214,059	107,914,357	(*e*)
Boston & Montana	57,987,633	60,746,000	60,250,000	60,000,000	62,000,000	79,000,000	66,200,000
Butte & Boston			4,500,000		7,000,000		16,950,000
Butte Reduction Works	2,282,000	3,390,000	4,225,647	7,883,795	9,685,088	10,049,629	12,455,772
Colorado Sm. & Mg. Co	5,158,730	7,750,000	9,090,680	8,911,578	7,657,938	9,572,155	11,453,940
Hecla Cons. Mining Co	362,897	239,631	312,445	215,431	121,089	155,719	131,494
Parrot	7,469,908	7,257,000	8,045,648	14,824,487	12,444,828	10,625,696	(*e*)
Montana Ore Purch'g Co	12,293,686	14,861,000	15,049,066	13,047,648	13,084,00)	15,360,679	22,257,563
Other Mines	2,011,901	750,000	4,242,583	804,474	(*b*)	5,775,716	125,011,944
Totals	183,094,755	194,768,925	*a*228,958,164	*c*237,158,540	*c*216,979,334	237,953,951	254,460,713

(*a*) In addition to 818,531 lb. of Canadian copper smelted by the Montana Ore Purchasing Co. and deducted in the above table, there was also deducted 1,000,000 lb. more of foreign copper estimated as having been included in the aggregate of the above returns, leaving the net amount 228,958,164 lb. (*b*) Included in reports of smelters itemized above. (*c*) Totals reported by E. B. Braden. (*d*) The individual reports include some copper derived outside of Montana, wherefore their sum exceeds the total as given. (*e*) Included under "Other Mines."

Of the important copper producing States, Montana was the only one that continued to respond to the stimulus of high prices by increasing its output. Nearly all of the companies reported a greater production than in the previous year, the Montana Ore Purchasing Co. taking precedence with an increase of nearly 7,000,000 lb. According to the annual report of the Mine Inspector of Silver Bow County there were 9,081 men employed in the mines at Butte, not including those working in the smaller properties. The Anaconda Copper Mining Co. continued the improvements on its reduction works, rebuilding and altering the entire plant. At the upper works Trent Chile mills with 6-ft. rolls and smaller mills of the Huntington type were substituted for the steam stamps. The last of the small matte furnaces have been taken out and replaced by larger furnaces, which, while not adding materially to the aggregate capacity, can be operated with greater convenience and economy. McDougal roasting furnaces are being installed, and so far as used have given good results. The Boston & Montana Copper & Silver Mining Co. produced 66,200,000 lb. of refined copper and disbursed $6,450,000 in dividends during the calendar year 1900, thus establishing a new record for the company. Its total receipts from sales of copper, silver, gold and bluestone amounted to $13,242,576·94, which after deducting $4,241,895·84 for expenses at Butte and Great Falls and electrolytic refining, and $807,828·62 for handling charges, gave an income of $8,192,852·18. The surplus on December 31, 1900, was $5,665,872·91. The construction work at Great Falls, begun in 1899, was brought nearly to completion at a cost for the year of $1,093,513·41, and the plant is now able to treat daily 2,000 tons of concentrating ore and 300 to 400 tons of smelting ore. According to the manager's report, the costs of calcination have been greatly reduced since the installation of McDougal furnaces. Some trouble was experienced with the water power, and the company proposes to erect an auxiliary steam power plant aggregating 2,500 H.P. The Parrot Silver and Copper Co. closed down its smelter at Butte and refineries at Bridgeport, Conn., the ores now being reduced at the Anaconda works. A concentrating plant was erected at Butte to treat the old tailings. Work at the Parrot mine was interrupted in the early part of August by a fire which destroyed the shaft house, hoisting machinery and compressor plant, inflicting a damage of about $30,000. By installing machinery taken from other mines owned by the Amalgamated Copper Co., operations underground were resumed after a brief delay. The erection of a permanent plant capable of handling 1,000 tons of ore per day, was nearly finished at the end of the year. The Montana Ore Purchasing Co., it is stated, is about to increase its reduction plant so that it will be able to produce 3,000,000 lb. of copper per month. Two new blast furnaces and four converters will be installed. The company secured its ore last year from the Rarus, Nipper, Minnie Healey, Clinton and Homestake mines, and it is engaged in sinking a new shaft on the Balm claim near the Gangnon mine. Suit was commenced by the Parrot Silver and Copper Co. to restrain the Montana Ore Purchasing Co. from carrying on operations in the 1,100-ft. level of the Nipper mine, it being claimed by the plaintiff that the ore bodies on that level apex within the surface boundaries of the Adventure claim.

Idaho.—The completion of the Pacific & Idaho Northern Railway to Council, 40

miles from Cuprum, has resulted in renewed activity in the Seven Devils district. Development work in the Blue Jacket mine and in those of the Boston & Seven Devils Co. has progressed favorably. Fifty carloads of high-grade ore were shipped to Salt Lake City and New York, the Blue Jacket mine contributing 1,000 tons of ore, which yielded approximately 765,000 lb. of copper and 10,000 oz. silver. The Snow Storm Mining Co., near Mullan, recently shipped the first carload of copper ore sent out from the Cœur d'Alêne mines. The average analysis is reported at 11·5% Cu, and 15 oz. silver per ton.

Nevada.—The Vulcan Copper Mining and Smelting Co. continued development on its group of claims at Siegelton, near Luning in the southwestern part of the State. A double compartment shaft has been sunk to the 300-ft. level and two cross-cuts run to the ore body which is said to average over 5% Cu, with 3 oz. silver and 1 oz. gold per ton. The company has secured land near by and is prospecting for coal deposits from which to draw the necessary fuel. A copper property 40 miles southeast of Lovelock is being developed by the Nevada Copper Co. A 50-ton smelter with the necessary equipments has been erected, and it is expected to begin production early in 1901.

New Jersey.—An interesting feature in connection with the advance in price of copper is the recent reopening of the old copper mines in New Jersey. Of these the oldest and most considerable is the Schuyler mine, at North Arlington, in Bergen County, which has recently been reopened by the Arlington Copper Co., incorporated at Trenton, N. J., with a capitalization of $2,500,000. Extensive works have been erected and a large force of men are employed at the mine. At First Mountain, near Somerville the American Copper Mining Co. has reopened the old Bridgewater mine, which first was worked in the eighteenth century, and has been operated at intervals since that time. In 1881 A. H. Harvey drove a tunnel 228 ft. into the hillside, from which he took ore which averaged 19% Cu and 6 oz. of silver to the ton, but for some reason the work was discontinued. Now a plant for operating the mine and treating the ore has been erected and work is going forward actively at the mine.

New Mexico.—The copper mines at Santa Rita, 14 miles east of Silver City, are now being worked by the Santa Rita Mining Co., Boston. These mines were operated by the Spaniards for many years and were finally abandoned by them in 1780. The ore was hoisted from the mines in buckskin sacks on the backs of miners, and after careful sorting was shipped by burros to Chihuahua or the City of Mexico. The present company have sunk three shafts and drifts are being run to connect them. The area owned by the company is about one square mile, and the center has been reserved for development. About 40 leasers are sinking shafts and an agreement has been made by which the company buys the ore running above 10% Cu for $1 per unit. The ore is mainly copper oxides and carbonates with considerable native copper and occurs in a stockwork of veins in a very soft decomposed porphyritic rock, the veins varying in width from knife-blade seams of native copper to 8-ft. wide bodies of low-grade oxidized ore. A 90-ton concentrator and a plant for leaching the tailings with sulphuric acid are supplied with material from the old dumps. At the end of the year the company was shipping upward of 1,000 tons of ore per month, assaying

between 10 and 20% Cu, to the Silver City Reduction Works, a branch of the American Smelting & Refining Co.

South Dakota.—The Black Hills Copper Co., the British American Gold & Copper Co., and the Copper Cliff Mining Co. have developed to some extent the copper belt of the Hornblende camp, 6 miles from Rochford, Pennington County. Assays of 2% Cu and $4 gold are reported for the ore taken from the surface of the vein.

Tennessee.—The production of copper ore in 1900 was 116,000 long tons, an increase of 26,279 long tons over the previous year. During 1900 the copper industry in this State employed 886 persons, of whom 465 worked in the mines. The Ducktown Sulphur, Copper & Iron Co. was the only active producer during the year, the Mary and Calloway mines contributing the output. The production, however, was limited by labor troubles. This company reports a net profit for the year 1899 of £17,406 which, exclusive of a small balance carried over to 1900, was dispensed as dividends. The Tennessee Copper Co. developed the old Burra Burra and London mines at Ducktown and is erecting large modern roasting and smelting plant which, with the 7 miles of railroad built to connect the Burra Burra mines with the Atlanta, Knoxville & Northern Railway, has cost $1,500,000. The company expects to produce copper matte early in 1901.

Utah.—The Horn Silver Mining Co. produced 1,534 tons of copper ore during 1900 in addition to its usual amount of lead-silver ores. The copper ores yielded 669,648 lb. of copper. The average value at the mine of the first class copper ore was $45·16 per ton.

Vermont.—Copper ore is being mined at present at the old Ely mine in Vershire, at the Elizabeth mine in South Strafford, at the Reynolds mine in Strafford and at the mine of the Vermont & Boston Mining Co. in Berkshire. It is stated that the developments on the Elizabeth mine up to 1900 show an ore body 1,000 ft. long, 240 ft. high and 35 ft. wide, carrying 3 to 6% Cu. At the Ely mine about 150 men are employed in making repairs and mining. The ore is smelted at the mine.

Washington.—The discovery of copper ore was reported at the Belcher and Hawkeye mines in Ferry County. A shipment of ore was made from the former mine to the Granby smelter at Grand Forks, B. C.

Wisconsin.—Kirby Thomas, in a paper read before the International Mining Congress at Milwaukee, Wis., June 22, 1900, described the general economic features of the Douglas range where, during 1900, four mines were under development: The Chippewa Copper Mining Co., the Percival, the Fond du Lac and the Colligen Co. The Wisconsin Geological Survey inspected the entire St. Croix district, which is practically a continuation of the Douglas range in 1899, and ore samples from the different properties assayed as follows: Colligen, 4·19% Cu; Fond du Lac, 0·39 to 1·99% Cu; Copper Creek, 9·29 to 1·6% Cu. It is questionable whether this property can ever be successfully worked as the copper is widely diffused and the ores in general are very lean.

Wyoming.—The Boston & Wyoming Smelting, Power & Light Co. is erecting a smelter at Encampment, Carbon County, which is to be in operation in 1901. The fuel will consist of charcoal and coke, the latter being hauled from

the Union Pacific station, while the wood and charcoal will be of local supply. The Battle Lake Tunnel Site Co. is driving a tunnel beneath its claims. At the end of the year it had progressed 100 ft.

Copper Mining in Foreign Countries in 1900.

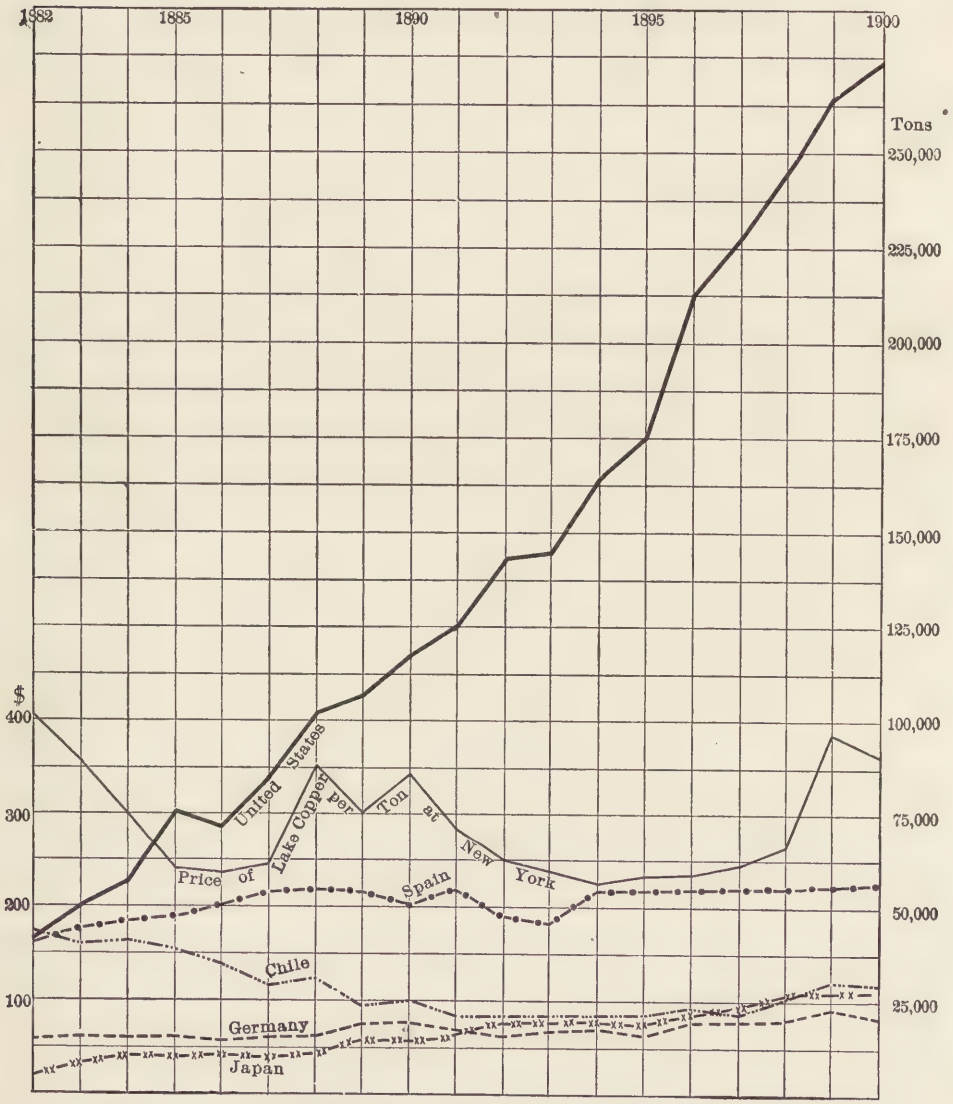
Australasia.—The union of the colonies into the commonwealth of Australasia, which became operative January 1, 1901, will doubtless have a beneficial effect on mining, and the uniformity of tariff and patent legislation will be of additional advantage in the development of the mineral industries of this country. The total production of copper in Australia during 1900 was 23,000 tons, against 20,750 tons in 1899. We are indebted to the courtesy of T. A. Coghlan, Government Statistician of New South Wales, for special information regarding the progress of the industry in the individual States. The copper mines of New South Wales are described in detail by L. Janin, Jr., in The Mineral Industry, Vol. VIII. Of these, the Great Cobar is the most important producer. At this mine work was recommenced in 1894, and during 1899, 122,829 tons of ore were raised and smelted, against 64,820 tons of ore in 1898. The hot blast furnace that was introduced in this year has been so satisfactory that all the smelting furnaces are to be supplied with hot air. It is a noteworthy fact that the copper extracted from the ore contains sufficient gold to exceed the cost of mining and smelting. In other portions of the Cobar district considerable activity has been displayed. At Nymagee, copper to the value of £35,125 was produced during 1900, and at Mt. Hope £10,498. The Burraga copper mine was acquired by an English company and great developments are promised. During the year copper was produced to the value of £36,400. At the C. S. A. and Wild Wave mines considerable prospecting has been done. W. B. Yates, of Sydney, has determined iodine in ores from New South Wales. The largest amount was 0·13% in a sample from the Cobar mines. Iodine in such small quantities is of no commercial value. Mr. A. J. Bensusan estimates the world's demand for iodine annually at 300 tons, the greater part of which is supplied from Chile, where it is produced as a by-product of the sodium nitrate factories. A large reserve stock of iodine is held by the Chile companies and enormous quantities are allowed to go to waste in order to maintain the price; with this in view it is beyond belief that iodine will ever be economically produced from the copper ores of New South Wales under existing circumstances.

Mr. G. H. Blakemore has designed and erected a water jacketed blast furnace 6·25×2·6 ft. section at the tuyeres for the Einasleigh Freehold Copper Co., Ltd., of Queensland; blowing-in, however, was deferred until after the rainy season. According to the report for the 16 months ending August 31, 1900, 990 tons of ore were mined, 700 tons of which came from the open workings and averaged 25% Cu, from 3 to 5 dwt. gold and 4 oz. silver per ton. In the Hampden copper mines a vein of chalcocite a foot wide has been struck which assayed 75·7% Cu. The extent of the vein has not been ascertained.

In South Australia the Burra-Burra mine remained idle as the deposits origi-

nally worked had become depleted, and the Wallaroo and Moonta mines, which were consolidated in 1890, were in active operation, employing over 1,800 men.

The expansion of the copper industry in Tasmania has been due chiefly to



THE WORLD'S PRODUCTION OF COPPER IN METRIC TONS

the enterprise of the Mt. Lyell Mining & Railway Co., Ltd. The ore from its mine at Gormanston is shipped 4 miles by rail to Queenstown, where it is smelted by the pyritic process. The railway from the reduction works to Teapookana

has been extended to Strahan, and it is stated that $2,000,000 was expended by the company in construction and development work before any return was received from the mines. The company employs over 1,800 men. The treatment of the Mount Lyell ore by pyritic smelting calls for the addition of iron-bearing fluxes, and it is interesting to note that in a typical furnace charge a greater amount of copper is derived from the North Lyell, Lyell Tharsis and Lyell Blocks ore fluxes than from the Mount Lyell ore. The entire ore body which had fallen into the Lyell Tharsis open cut, amounting to 2,000 tons, has been sent to the smelters and the broken ore body lying above the stoped ground, estimated to contain 20,000 tons of 5% Cu grade, will be removed by a further extension of the open-cut system. The South Tharsis mine has been taken over by the company at a price of £45,000, and ore of fair quality has been removed

THE WORLD'S COPPER PRODUCTION, 1896—1900. (*a*)

Countries.	1896.		1897.		1898.		1899.		1900.	
	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.
Algeria	*Nil.*	*Nil.*	*Nil.*	*Nil.*	50	51	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Argentina	100	102	200	205	125	127	65	66	75	76
Australasia	11,000	11,176	17,000	17,272	18,000	18,288	20,750	21,082	23,000	23,368
Austria-Hungary	1,285	1,306	1,655	1,681	1,540	1,565	1,505	1,529	1,355	1,377
Bolivia	2,000	2,032	2,200	2,235	2,050	2,083	2,500	2,540	2,100	2,134
Canada	4,190	4,225	5,905	5,999	8,040	8,169	6,730	6,838	8,446	8,581
Cape of Good Hope Cape Company	5,470	5,558	5,290	5,375	4,660	4,735	4,140	4,206	4,420	4,491
Namaqua	1,980	2,012	2,150	2,215	2,400	2,438	2,350	2,388	2,300	2,337
Chile	23,500	23,876	21,900	22,250	24,850	25,248	25,000	25,400	25,700	26,111
Germany—Total	20,038	20,365	20,145	20,467	20,085	20,407	23,460	23,836	20,310	20,635
(Mansfeld)	(18,238)	(18,536)	(17,960)	(18,247)	(18,045)	(18,334)	(20,785)	(21,118)	(18,390)	(18,684)
Italy	3,400	3,454	3,480	3,536	3,039	3,088	2,965	3,012	3,000	3,048
Japan	21,000	21,336	23,000	23,368	25,175	25,578	28,310	28,763	27,840	28,285
Mexico—Total	11,150	11,338	11,370	11,553	15,668	15,919	19,005	19,310	22,050	22,403
(Boleo)	(9,940)	(10,099)	(10,170)	(10,334)	(9,436)	(9,587)	(10,222)	(10,386)	(11,050)	(11,227)
Newfoundland	1,800	1,829	1,800	1,829	2,100	2,134	2,700	2,743	1,900	1,930
Norway	2,500	2,540	3,450	3,505	3,615	3,673	3,610	3,668	3,935	3,998
Russia	5,100	5,181	6,025	6,121	6,000	6,096	7,210	7,325	8,000	8,128
Peru	740	75[1]	1,000	1,016	3,040	3,089	5,165	5,248	8,220	8,352
Spain-Port.—Total	53,347	54,203	54,060	54,925	53,225	54,075	54,220	55,088	52,872	53,718
Rio Tinto	34,501	35,055	33,900	34,442	33,705	34,244	34,370	34,920	35,732	36,304
Tharsis	11,040	11,217	12,000	12,192	12,000	12,192	9,448	9,599	7,965	8,092
Mason & Barry	3,381	3,435	4,300	4,369	3,600	3,658	3,600	3,658	3,460	3,515
Sevilla	1,025	1,041	810	823	800	813	1,200	1,219	1,460	1,483
Sweden	500	508	545	554	480	488	520	528	450	457
United Kingdom	580	589	555	564	640	650	637	647	650	660
United States	208,760	212,112	223,825	227,420	239,241	243,069	259,517	263,685	268,229	272,536
Totals	378,440	384,493	405,350	412,088	434,023	440,972	468,423	475,934	484,852	492,625

(*a*) The figures in this table are taken from the annual metal circular of Henry R. Merton & Co., except where returns have been received by THE MINERAL INDUSTRY direct from official sources.

at both benches, supplying the furnace with 80 tons daily. The copper pyrites is well distributed throughout the rock and appears to be of higher grade as the faces of the benches advance and gain depth. Several advantageous changes have been made at the mill and with a resultant increase in the richness of the concentrates. The Mt. Lyell Mining & Railway Co., Ltd., reports that during the semester ending September 30, 1900, the amount of ore raised was 144,301 tons, of which 126,240 tons came from the open-cut workings and 18,061 tons from underground. The average assay was 2·48% Cu, 1·95 oz. silver and 0·074 oz. gold per ton. In addition 22,920 tons of ore from outside mines were treated, making the total amount of ore passing through the smeltery 167,221 dry tons. The amount of converter matte treated was 10,349 tons, producing 4,768 tons

of blister copper, averaging 98·85 Cu, 69·6 oz. silver and 2·5 oz. gold. The cost of making this copper was $5·3836 per ton of ore of 2,000 lb. divided as follows: Mining, $0·82; removal of overburden, $0·48; smelting, $3·5978; converting, $0·4858. This is a reduction of $0·1516 compared with the preceding semester, and $0·2299 less than in the corresponding half year of 1899. Arrangements were made with the Baltimore Copper Smelting & Rolling Co. for refining the blister copper. Under the agreement, which is to run for three years, the Baltimore company receives a fixed payment for the separation of the metals. The refined copper and silver are sold at New York under the board's directions, while the gold is deposited at the United States mint. During the half year the net profits amounted to $553,943 and $669,625 were distributed in dividends. The North Mt. Lyell Copper Co. is to install four reverberatory furnaces of the American type, each of a capacity to treat over 200 tons of ore daily. In addition to these a converter plant is to be erected to treat the entire matte product of these furnaces. Total cost is estimated at £90,000.

The Anaconda Co. near Murrin, West Australia, has opened up by open-cut work a large body of ore that is stated to contain about 25% Cu. A second furnace will be erected as soon as the railroad connection has been made with the proposed government extension from Menzies.

Canada.—The greater part of the copper ore output of British Columbia was derived from the Boundry Creek district, which produced 5,672,177 lb. fine copper in 1900. At Rossland, the main producers were the Le Roi, Center Star, War Eagle and Iron Mask mines. The Velvet mine on Sophia Mountain has been brought into prominence during 1900. The assay value of the ore at the 300-ft. level has been reported at $82 per ton. An important feature of the industry in this district is the greatly reduced cost of mining and treatment. The ore shipments from the Le Roi mine for 1900 were 149,246 dry tons of an average value of $14·15 per ton. The average cost of mining was $3·25 per ton. This work was done with the old machinery. The new 5-compartment shaft at the end of the year was down to the 900-ft. level and new machinery in connection with the shaft will be started early in 1901. The plant of the Canadian Smelting Co. at Trail has increased its capacity and the reduction made in the cost of ore treatment during the past two years has been of great advantage to miners of low-grade ore. The Le Roi Mining Co., Ltd., has acquired the remaining one-quarter interest in the Northport smelter for $300,000, and is enlarging the plant to a capacity of 1,000 tons per day. The cost of smelting at the end of 1900 is stated to be about $4 per ton. Two new copper smelters have been erected and put into operation during the year; the plant of the Granby Consolidated Mining and Smelting Co., at Grand Forks, and the one of the British Columbia Copper Co., near Greenwood. These smelters are referred to under the metallurgical notes on copper smelting, given later in this section. The British Columbian Exploration Syndicate operated the Iron Mask and Lucky Strike mineral claims in the Lillocet district with satisfactory results. On Copper Mountain the ore bodies are of great extent and assay 4 to 5% Cu and $2 in gold and silver per ton. The Old Ironsides group of mines in the Slocan district produced ore estimated at $8 to $10

per ton in copper and gold values and averaged 600 tons daily output with a probable development to 1,000 tons or more. The ore is sent to the Granby smelter at Grand Forks. The production from the Deadwood camp up to October 31, 1900, was estimated at 54,000 tons. While of low grade, the enormous extent of the ore deposits are worthy of note. The St. Eugene mine, at Moyie, Kootenai, has made its first shipment of ore to a Chilean smelter, under a contract for $1,000,000 worth. The sacked ore is consigned to the Canadian Pacific Railway at Vancouver, thence via steamer to Chile, where it is used in combination with the dry ores of that country. The copper deposit on Gribbell Island, 400 miles from Vancouver, is being developed. The principal vein is stated to be 8 ft. wide and extends across the island. Trial shipments have been made to the Tacoma smelter for the purpose of testing the ore thoroughly. The Van Anda properties on Texada Island have recently been taken over by an English company, which is reported to have paid $500,000 for 85% of the stock. The former stockholders are to receive a dividend as well as a partial interest in the new company. In all $600,000 has been spent on the property. The smelter has been remodeled and enlarged to 125 tons capacity per day. A discovery is reported of a large body of low-grade copper ore in the Britannia mine on the east side of Howe Sound, 28 miles from Vancouver. The Monitor Copper Mining Co.'s mines on Alberni Canal shipped 566 tons of ore to the Tacoma smelter on December 15, 1900. Exploration work conducted by the Cape Breton Copper Co. at Coxheath, Cape Breton County, Nova Scotia, has proven a number of copper ore deposits extending several thousand feet and of depths of 300 ft. and more. The deposits vary up to 12 ft. in thickness and are bedded in pre-Cambrian felsites and slates. While a few of the lenses contain ore of 10% Cu content the general product will require concentration. Working tests have shown the concentrated material to be exceptionally pure. Detailed tables of ore analysis and results of concentration work by the Humboldt Works at Kalk, Germany, are reported by E. Gilpin, Jr., in the *Transactions of the Nova Scotia Institute of Sciences,* Vol. X.

Bolivia.—The chief production of copper is derived from Coro Coro in the Province of La Paz, where there are two distinct sedimentary formations. Native copper is common to both in the form of fine irregular grains (barilla) assaying from 60 to 92% Cu and in masses (chaquins) occasionally of large size. Vanadium is present in the Coro Coro cupriferous sandstones—an occurrence long known as particularly characteristic of the copper schists at Thuringia, Germany. At present the mined ore is washed and concentrated to a product called "Barilla," which contains about 70% Cu. The principal mining companies in the Coro Coro district and their production in 1897 in tons of 2,240 lb. were: Compañia Coro Coro, 1,089; Noel Berthini, 371; Carreras Hermanos, 364; and J. K. Child & Co., 196; total, 2,886 tons. In 1899 the production amounted to 2,500 tons. The shipments pass through Molendo, Peru.

Chile.—The restricting conditions that affect the output of Chilean copper are due to a variety of causes, the most serious being scarcity of skilled labor, heavy duty on imports of dynamite and lack of suitable reduction works at favorable points. Of the 18 metallurgical establishments in operation in 1894, only

nine were running in 1900, and three of these, the Tierra Amarilla, Guayacan and Lota, turned out three-fourths of all the copper exported. There appears to be a very good field for works in northern Chile which would use the wet method of treating the oxidized ores. The copper mines of Chuquicamata, 15 miles from Calama, Antofagasta and about 2,500 ft. above it, resemble a quarry of small loose material, requiring no blasting. The deposit is 3 miles long and 0·75 miles wide, and of unknown thickness. In one of the deepest holes (40 ft. in depth) a lode of pyrites measuring 53 ft. across and yielding 50% Cu has been struck. The layer itself is composed of shattered feldspar and atacamite, the interstices being packed with dust of the latter of an average assay of 12% Cu. Mining is done in a very primitive manner; the material is excavated and removed, leaving immense caves or tunnels. Each working is in charge of a squad of three men. One with a pick and shovel dislodges a quantity of the naturally loose material from the walls of the cave, the second screens it with a 30-mesh sieve, forming a heap of fine stuff which is subsequently sacked for shipment and rejecting the coarse, stony portion which is wheeled by the third to the mouth of the cave and dumped down the hillside. The discarded material carries considerable ore with it in adhering layers, sometimes 0·25 in. thick. Each man earns from $5 to $15 national currency per day. The present inadequate facilities for handling the production will be bettered by the construction of the branch of the Antofagasta Railway to Chuquicamata and will hasten the development of this very rich deposit. The erection of a plant for the wet treatment of these ores could be easily established on the banks of the Loa River, and the production of sulphuric acid for their treatment is made easy by the presence of large quantities of sulphur in the vicinity. At present from 2,000 to 3,000 tons of fine ore, averaging 12 to 18% Cu is exported monthly to Europe. Immense deposits of oxidized copper ore have been reported 35 miles from Lagunas, Tarapaca. The ore contains from 2 to 3% Cu, of which from 70 to 80% is sulphate and the balance nearly oxide. The gangue rock is very friable and lends itself to easy leaching. Ample water power is available and with cheap labor the exportation appears very promising. According to J. Velásquez Jiménez, *Anales de la Sociedad Científica Argentina,* 1899, the high mineralization of the sulphides does not cease at depths of 1,000 to 1,500 ft. He quotes in support of his theory the Dulcina mine, Copiapo, operated by a British company, which extracts profitable ore at 2,300 ft. depth and greater. The pyritiferous leaders assay 20% Cu. The present mining operations are greatly handicapped by the wasteful manner in which the ore was extracted in the excitement during the copper corner in 1887-1889. The Copiapo Mining Co., Ltd., reports a net profit of £46,273 for the fiscal year ending June 30, 1900. The average price of copper for the year was £74 9s. 6d. or £11 16s. 6d. above that of the previous year, but the returns to the company were offset by increased cost of wages, materials, freights and, particularly in the latter half of the year under review, the large cost of coal, which adversely affected the sale of the ore, the smelters being unable to pay as high prices as in the previous year. The Copper Corporation of Chile, in the report for the fiscal year ending

March 31, 1900, states an unsatisfactory condition of the year's operations, due to scarcity of labor and other untoward circumstances. A reorganization of the company's affairs in Chile was being made. The Antofagasta Copper Co., of Valparaiso, has recently been organized with a capital of $325,000. Its object is the exploitation of 29 copper mines in the district of Chuquicamata, in the Department of Antofagasta, and a smelter is in contemplation. The Compañia Explotadoro de Minas de Cerro Blanco, with a capital of $195,000, has been organized to exploit mineral deposits in the vicinity of Cerro Blanco. The International Mining and Refining Co. of Huantajaya, has been incorporated with a capital of $300,000 to exploit mines in the Huantajava district. The Exploration Co., of Chuquicamata, also with offices at Valparaiso, has been organized to exploit copper mines in Antofagasta. The Copaguire mines, which were purchased by Gibbs & Co., for £35,000, have been sold to the German bank for £120,000. A company will be formed to operate them. A discovery of rich copper ores assaying 60% Cu has been reported in the Loncomilla district. A Chilean smelter contracted for $1,000,000 worth of ore from the St. Eugene mine, Kootenai, B. C., to be used in combination with the dry ores of Chile.

EXPORTS OF COPPER FROM CHILE AND BOLIVIA.

	1896.		1897.		1898.		1899.		1900.	
	Quintals.	Fine.	Quintals.	Fine.	Quintals.	Fine.	Quintals.	Fine.	Quintals.	Fine.
Bar copper	459,380	459,380	418,665	418,665	448,585	448,585	400,955	400,955	442,174	442,174
Copper regulus...	67,945	34,506	86,538	42,661	81,141	41,930	72,006	32,949	105,172	45,236
Copper ores.....	133,712	24,139	94,550	20,786	324,919	64,023	646,028	118,193	439,406	77,652
Total.		518,025		482,112		554,538		552,097		565,062

NOTE.—The quintal is 101·5 lb. avoirdupois.

China.—Despite the disturbed conditions brought about by the war, considerable prospecting has been carried on during 1900, and it is stated that the copper mines worked centuries ago and then abandoned because of the lack of fuel can now be profitably exploited by the aid of coal from the neighboring mines.

Costa Rica.—The famous old copper mine, Las Concavas, near Cartago, has been reopened and work begun, and a rich copper mine has been discovered between Orosi and the General Plains on the Pacific side.

Cuba.—Considerable attention has recently been attracted to the possibilities of the "El Cobre" mines, situated 12 miles northwest of Santiago de Cuba, in the foothills of the Sierra Maestra. The deposits of copper at El Cobre were known and worked in the early part of the sixteenth century. After the conquest of Peru, the attention of the Spaniards seems to have been attracted to the mineral wealth of that country, and the mines near Santiago de Cuba received only occasional notice until about the year 1834, when an English company reopened the old mines. Between 1830 and 1870, copper ore to an amount estimated at 696,707 tons, valued at £6,722,554, was shipped to Swansea, England. As a result of the Cuban insurrection of 1868, pumping was stopped, and since that time the workings have remained flooded. In 1869 the mines were finally made over to the Spanish Railway Co., who operated a railroad between

El Cobre and Punta del Sol on Santiago Bay, to satisfy claims for the transportation of ore. The railroad, partly destroyed in the insurrection of 1868, has never resumed operations and work at the mines is limited to the extraction of a little copper from the surface water. After the reopening of the mines by the English company in 1834, other properties were opened in the district. These have also remained idle since 1869, but one of them, the San José, has been relocated. Recently some New York gentlemen have obtained a lease of the Spanish Railway Co.'s property, and a refusal of the two most important of the remaining mines, and an attempt to resuscitate the copper industry at El Cobre is about to be made. A pumping plant with a capacity of 500 gal. per minute has been installed at one of the shafts, and experiments are being carried on with a view to extracting copper from the water with which the mines are flooded. From the amount of ore shipped and the size of the old dumps of low-grade ore, it is evident that the underground workings are very extensive. As far as is now known none of the shafts exceed 1,000 ft. in depth. The ore in the old dumps is undergoing decomposition, yielding copper to the surface water, from which some copper is obtained by treatment in rude tanks with iron derived from the abandoned machinery. As the water in the mine shafts contains a higher proportion of copper than the surface water (analysis yielding 1·07 lb. per 1,000 gal. for the former to 0·97 lb. for the latter) it is probable that the 500 to 800 tons of iron left in the shafts has been mostly replaced by copper.

India.—A report on the administration of Sikkim in the year 1899-1900 states the discovery of new finds of copper ore at Rhenok, on the Rishi River, below Rinchenpong, and at Bodang Khani. A sample of ore from the latter place gave the following analysis: Fe, 27·00%; Cu, 3·55%; SiO_2, 0·35%; Pb, 1·53%; As, 0·24%; Zn, 2·40%; Ni, 0·70%; Al_2O_3, 6·78%; S, 18·72%; SiO_2, 38·02%; H_2O, 9·25%; silver approximating 2 oz. per ton. The ore is distributed over a hill a quarter of a mile square, and there appears to be a great quantity of it. With a slight expenditure, water power would be available. A large deposit of lime has been found in the Rishi valley and coal also occurs up the Rungeet valley, but its quality is very poor. The natives are not able to work the ores profitably. According to R. G. Elwes there exists in Chota Nagpur, Bengal, about 120 miles south of the Baragunda mines, a belt of cupriferous metamorphic rocks extending 80 miles N.W. and S.E. Numerous native workings and masses of scoria scattered along the belt indicate the existence of a great industry in ancient times. The schists and quartzites are permeated for hundreds of feet in thickness, with small quantities of copper ore, chiefly chalcopyrite, but only in a few seams of moderate width has the ore so far been found sufficiently concentrated to form payable deposits. A section of these strata has been satisfactorily explored to a depth of 230 ft. by a local company, and preparations are being made to work the deposits on a large scale.

Italy.—The copper deposits between San Vincenzo and Campiglia, which were mined by the early Romans, have recently been purchased by an English company and systematic exportation begun. Several lodes of copper sulphide and one of galena and zinc blende have been surveyed and are now being worked. The lodes are reported to be true fissures forced up through a ground work of

clay slate which is overlaid by a bed of white marble of from 400 to 600 ft. thick. A portion of the ore assays 22% Cu and practically all the material taken from the shafts and tunnels has been rich enough to smelt. Cheap labor, easy access to the sea, large supply of iron and limestone are very favorable factors for the development of the region.

Japan.—Although copper was discovered in Japan A. D. 698, smelting on a large scale was not developed until early in the seventeenth century. Dr. Geerts of the Asiatic Society estimates that from the beginning of the industry 280,000 short tons were exported by the Dutch and 250,000 by the Chinese. At present about one-half of the production is consumed at home. The chief ore is chalcopyrite, generally associated with pyrite, pyrrhotite, galena and often with sphalerite. Native copper and oxidized ores are rare. Tetrahedrite, arsenopyrite and native bismuth contaminate the ores only in a few localities and stibnite is of rare occurrence. Silver is frequently present and is largely extracted from the crude copper which generally contains from 25 to 200 oz. silver per ton. Gold occurs in the copper from Towata up to 5 oz. per ton. More than 60% of the total production of the country is derived from the following mines, arranged in the order of their importance: Ashio mine, in Shimotsuke; Besshi mine, in Iyo; Ani and Arakawa mines in Ugo; Osarusawa mine in Rikuchu; Kusakura mines in Echigo; the Ogoya mine in Kaga. The Ashio mine is now down 1,500 ft. and is well equipped with modern machinery, mostly made in Chicago, Milwaukee and San Francisco. The Besshi mine possesses large bodies of low-grade copper pyrites, which are matted at the mines and in the adjacent city of Nihama, the matte being smelted later to 99% fine, in reverberatory furnaces at the town named. Japan exported 21,131 long tons of refined copper in 1899, valued at $5,000,000. Although many of the copper mines in Japan have been worked for one or two centuries they are not on that account even partially exhausted, as until recently it has been impossible to exploit them beyond small depths, owing to the difficulty in removing the water with the old appliances.

Mexico.—As in the past the chief part of the production of copper in Mexico during 1900 has been derived from the Boleo and adjacent mines of Lower California, though recently the Nacosari mines have added largely to the total output. The Compagnie de Boleo produced 11,227 metric tons of copper in 1900, against 10,386 metric tons in 1899, and has rebuilt the smelting works. The fine ore which constitutes more than one-half of the mined product is removed by hand sorting and screens and briquetted in three machines, each handling 25 tons per hour at an expense of 1 fr. per ton. The clay in the ore serves as a binder. Seven water-jacket furnaces are in operation, the newer ones being of 145 tons capacity per day. The copper water jackets formerly in use have been replaced by steel, as the latter metal better withstands the corrosion of sea water. Black copper and matte are tapped from the furnace together, and subsequently separated. The black copper assays 96% Cu, 0·84% Fe, 0·77% S, with small amounts of lead, zinc, nickel, cobalt, antimony and phosphorus. The matte contains 64% Cu, 22% S, 10% Fe and a small amount of manganese in addition to the metals above enumerated. The final product contains 99·75% Cu. The coke consumption is 15% of the charge, and is brought from West-

phalia and Wales via Cape Horn. The matte and black copper are shipped to Europe for refining, a part via Guaymas by steamer, thence to New Orleans by rail and loaded as ballast in steamships in the cotton trade, while a certain amount is shipped direct. The Moctezuma Copper Co. (Phelps, Dodge & Co., of New York) owns and operates the Nacosari mines 98 miles south of Bisbee, Ariz. The new mill, smelter and railroad equipment represents an investment of $3,000,000. The Cananea Copper Co. has secured a contract from the government of Sonora to establish a 200-ton smelter at Cananea. The group of copper mines in the State of Coahuila has been purchased by the Rothschilds house in Mexico for $600,000. This company owns the Boleo mines in Lower California and the Inguaran mines in the State of Michoacan. Its total holding of copper properties in Mexico is valued at $14,000,000. The Panuco Copper Co., owned by an English company, went into the hands of a receiver who proposes to close out the company, disbursing the £100,000 in hand as a 4s. dividend.

Newfoundland.—The Cape Copper Co., Ltd., reports a net profit of £59,299 for the year ending April 30, 1900, and states that development work was actively carried on during the year. An interim report up to August 31, 1900, gives the year's output from the East mine as 65,010 tons, averaging 3·42% Cu, which was mined at a cost of $1·05 per ton and 3,398 tons averaging 10·34% Cu from the West mine. Two-thirds of the product was shipped to New York, the balance going to Swansea. The copper mine at York Harbor, Bay of Islands, has been sold to an English company for £30,000. There is about 2,000 tons of copper ore on the surface and about 17,000 tons in sight.

Norway.—The Röris copper mines produced 31,000 tons of ore in 1899. Of this, 13,000 tons were export pyrites and from the balance 735 tons of copper were produced against 583 tons in 1898. The mines have been reconstructed and equipped with electric power and employ 600 men. The Sulitjelma copper mines produced 44,000 tons of ore, of which 31,000 tons were export pyrites containing 44 to 45% S and 4% Cu. The 13,000 tons balance produced a little over 500 tons of copper. Three new mines of good promise were opened up in 1898-1899. These mines, the largest in Norway, employ at present 780 men. It is contemplated to extend the mining interests very largely. The entire Jacob Valley pyrites field still lies untouched as a reserve. At Lyngen in the Tromsö district, a new copper plant will be started to treat ore from a neighboring mine which produced in 1899 8,300 tons of copper ore containing from 8 to 9% Cu. The working of all the copper and pyrites mines in 1899 employed about 2,050 men, yielding a total approximating 130,000 tons of pyrites and copper ore, of which from 90,000 to 95,000 tons were exported. The copper produced from domestic ores amounted to 1,250 tons.

Peru.—Copper mining is attracting more attention each year as is evidenced by the rapid increase in the exports. There are three districts where copper deposits are seriously exploited: Ica, Cerro de Pasco and Yauli and Morococha. The principal mine in the Ica district is the Canza, about 12 miles distant from Ica, which yields rich ore but is not well located as to fuel and water. In the Yauli and Morococha region there are several mines under exploitation, but

owing to the high costs of transportation they have not yet become large producers. The richest deposits are in the district of Cerro de Pasco, which is soon to be connected by railway with Callao. Mining conditions here are said to be very favorable. A company known as the Socavon del Cerro de Pasco, has been formed with a capital of 1,200,000 soles, to engage in copper smelting and refining. The company plans to extend the railroad from Oroya and to build a new line to the coal fields of Chacayan, also to erect smelting works.

Philippine Islands.—Deposits of copper ore are known to occur at Mindanao, Negros, Panay and southern Luzon, some of which contain gold in notable quantities. With the introduction of modern machinery and methods of working the mining industry should become important.

South Africa.—The Cape Copper Co., Ltd., for the fiscal year ending April 30, 1900, reports a production of 21,032 net dry tons, averaging 18% Cu, from the Ookiep mine and 619 tons from the Spectakel mine, averaging 30·13% Cu. The old smelting plant produced 18,894 tons of matte assaying 48·9% Cu, and the new smelting works at Nababeep began operations on May 15, 1900. The Namaqua Copper Co. reports a production of 9,000 tons of copper ore during 1899, which yielded a net profit of £118,751; dividends during the year amounted to 40%. The district is connected with the port of Nolloth on the Atlantic coast by the narrow gauge railway 91 miles in length of the Cape Copper Co. The bulk of the ore is chalcopyrite, containing from 20 to 30% Cu, with an occasional bornite association; black and red oxides are found in small quantities at considerable depth, while the carbonates and silicate are always in evidence near the surface. The Ookiep mine is operated by two vertical shafts and the deposit is largest in section at the 70-fathom level, where it is about 360 ft. wide and 280 ft. in height. The ore, consisting chiefly of purple and yellow sulphides, is concentrated. About 300 tons of crop ore (the richest of the dressed ore) and 500 tons of mine smalls are shipped per month. From 1,600 to 1,700 tons of middlings and yellow ore per month go to the cupolas, either direct or through the calciners. Roasting is done in stalls and occupies from four to eight weeks and the ore is smelted in three circular cupola furnaces. The charge of mine seconds containing feldspathic quartzose gangue, roasted pyrites, iron ragging, etc., is comparatively low in iron, and easily smelted. The slags contain from 0·25 to 0·75% Cu and the matte, averaging about 50% Cu, is shipped to Swansea, Wales. The Tweefontein mine produces monthly from 350 to 400 tons of selected ores, running from 28 to 30% Cu and 400 tons of finer material, averaging 27% Cu. The ore is dressed and magnetic separators serve to relieve the ore (before washing) of any magnetic iron that is heavier than the copper pyrites and consequently would interfere with the action of the jigs, and to reduce, after jigging, the weight of the concentrates, thus saving transport. Any slimes below 1 mm. that are too poor for bagging are further concentrated by buddles. In Rhodesia copper ores have been found north of Zambesi, near the Kafuke River in territory belonging to the Northern (B. S. A.) Co., Ltd., and Mr. Lewis, the representative of this company, has recently reported a large number of ancient workings in the district. Other discoveries of copper ore further north have been reported by the Tanganyika Concessions and in the area

of the Dr. Carl Peter's Estates & Exploration Co., Ltd., in the Meisetter district.

Spain.—The Rio Tinto Co., Ltd., during 1900, realized on sales of copper and other items, including the balance brought down from the previous year, a total of £1,669,560. Out of this amount, the sum of £63,240—for the redemption of the 4% mortgage bonds—and other sums amounting in all to £100,945 were set aside, £65,000 was placed to the reserve and provident funds and £22,666 written off for extension, development and other accounts. The total balance was £1,480,950, out of which an interim dividend of 2s. 6d. per share on the preference shares, less income tax, and 40s. on the ordinary shares, amounting in all to £688,932 were paid, and a final dividend of 2s. 6d. per share on the preference shares and of 45s. per share on the ordinary shares, amounting to £769,844, was recommended, leaving a balance to be carried forward of £22,174. The total quantity of ore extracted during the year was 1,894,504 tons, averaging 2·74% Cu. There were invoiced to consumers in England, Germany and the United States 665,967 tons, with a total copper content of 14,612 tons, which with the copper extracted at the mines gave a total output of 35,732 tons. It is estimated that the reserve heaps at the mines contain 128,016 tons fine copper, while the stocks at the company's works at Cwmavon, consisting of refined copper, copper in process, precipitate and matte, amounted to 5,992 tons.

Venezuela.—There are copper workings at Curuaragua, Titiara Quebrada and San Antonio, which have produced large amounts of ore in the past. The total output of fine copper from 1872 to 1894 was about 65,000 long tons, mostly from the Quebrada mine under the operation of an English company. The resources of the mines are thought to be still large, although their exploitation ceased several years ago.

The Copper Markets in 1900.

New York.—After the extraordinary activity of 1899 it was not unreasonable to expect that during 1900 consumption would decrease and much lower values for copper be established. The political situation the world over was not favorable; in the United States a presidential campaign was pending, in Europe the English reverses in South Africa tended to disturb the financial situation. In the face of these adverse conditions the market during the past year was remarkably steady. While at no time prices soared as high as in August, 1899, when for a while Lake copper sold at 18·5c., the average price of electrolytic copper in New York was 16·19 as compared with 17·61c. for 1899, the fluctuations being much less violent.

During 1899 the demand for copper was almost constantly in excess of the supplies, and thus for many months spot copper demanded a considerable premium. During 1900 the product was always adequate to supply the demand; and there was, furthermore, a tendency on the part of the manufacturers generally to work up their stocks and carry less copper. Thus, at different times during the year, there were but few buyers of the metal, and the market became dull, but as the metal is held in very strong hands, values did not suffer, and buyers soon had to replenish their stocks and relieve the producers of their holdings.

It appears that the total consumption in the United States has not changed.

The output of brass has been somewhat less, but that of conductivity wire has correspondingly increased. The consumption abroad has shown a large increase, both on the Continent and in England. In the latter country demand was especially brisk, and the installment of electric traction and power has called for enormous quantities of copper.

Exports from the United States show a remarkable increase, being this year 137,800 tons, as against 114,360 tons last year. The United States has still further strengthened its position as the dominant factor in the copper market.

The London market for standard copper has lost its former significance, as at times it moved quite out of harmony with the course of the market for refined copper. Early in the year it was possible for some large operators to obtain control of the stocks of Standard copper; in consequence early deliveries rose sharply and a backwardation of £5 resulted. Meanwhile electrolytic copper had been selling much below standard.

The year opened with Lake copper selling at 16·25c., electrolytic at 15·625c. The market was quite steady. When, early in January, the price of manufactured copper was reduced, the demand was greatly stimulated, and a domestic business resulted. Large export orders also came to hand, and early in February an active market resulted. At this time one of the largest producers consummated a sale of some 15,000,000 lb. for delivery up to June at 16c. The market became very steady, for previously buyers in general were nervous as to just what course the market would take. Electrolytic copper sold at 15·875c., and it is to be observed that while this description had advanced, Lake copper had declined slightly. The chief reason for this is to be found in the fact that at that time the European demand was very strong, and that its requirements are mainly for electrolytic copper.

The market during March continued firm and active. Europe continued to call for constantly increasing quantities, and exports for this month reached the tremendous figure of over 20,000 tons. Meanwhile manufacturers here had quite depleted their stocks, and came forward as heavy buyers, so that it was hardly possible for the refiners to meet the demand. The price advanced to 17c. for Lake copper and 16·625c. for electrolytic copper.

During April the market was very quiet, and there was not much business, either foreign or domestic, but in the absence of any pressure to sell, Lake copper continued to find buyers at 17c., electrolytic copper at 16·75c. In May, however, the continued dullness made itself felt, and Lake copper sold down to 16·25c., electrolytic at 16c. These conditions prevailed until July, when once again a buying movement set in, and Lake copper changed hand at 16·375c. and electrolytic copper at 16·125c. During August the foreign demand became very pressing. The great heat which prevailed interfered seriously with production, and refiners were much in arrears in their deliveries. Europeans whose stocks, in spite of the large shipments from this country, had been worked up, were calling for prompt copper, and the result was that this became quite scarce. Lake copper sold at 16·625c. and electrolytic at 16·5c.

Throughout the fall the market was very quiet. Manufacturers, both in this country and in Europe, were inclined to work with smaller stocks. Here the

presidential election, and in Europe the Chinese trouble, caused a cloud to hang over the market. That values did not suffer more is to be ascribed to the fact that the producers had sold well ahead and were confident of a favorable outcome of the situation. Meanwhile Lake copper sold down to 16·5c. and electrolytic at 16·25c.

The re-election of Mr. McKinley early in November completely changed the aspect of the market, and brought forward American and European buyers for delivery as far ahead as next spring. Throughout the world stocks in the hands of manufacturers had become very small. Prices gradually advanced, and Lake copper sold at 17c. and electrolytic at 16·5c.

During early December the market became quite dull again, but toward the end of the month a better demand from Europe made itself felt. The year ended with Lake copper selling at 17c. and electrolytic copper at 16·25@16·375c.

AVERAGE MONTHLY PRICES OF LAKE COPPER IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1896	9·87	10·64	11·03	10·98	11·15	11·67	11·40	10·98	10·66	10·66	11·23	11·28	10·88
1897	11·75	11·92	11·80	11·48	11·03	11·11	11·11	11·16	11·30	11·13	10·88	10·78	11·29
1898	10·99	11·28	11·98	12·14	12·00	11·89	11·63	11·89	12·31	12·41	12·86	12·93	12·03
1899	14·75	18·00	17·54	18·43	18·25	17·93	18·33	18·50	18·46	17·76	16·93	16·40	17·61
1900	16·33	16·08	16·55	16·94	16·55	16·00	16·16	16·58	16·69	16·64	16·80	16·88	16·52

AVERAGE MONTHLY PRICES OF ELECTROLYTIC COPPER IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899	14·26	17·02	16·35	17·13	17·20	16·89	17·10	17·42	17·34	16·94	16·49	15·85	16·67
1900	15·58	15·78	16·29	16·76	16·34	15·75	15·97	16·35	16·44	16·37	16·40	16·31	16·19

London.—The London metal markets during the past year fluctuated considerably, owing to the many side issues which affected them. The continued hostilities in South Africa caused a spirit of unrest to pervade all branches of trade. The never-failing belief in the eventual British success prevented any great break in prices, but "hope deferred maketh the heart sick," and the outside public became disappointed and the markets during the middle and latter months of the year were left to a great extent in the hands of professional operators. It became evident that the zenith of the metal boom had been passed, and although the demand for raw materials was still very large, the buying was spasmodic, and of a hand-to-mouth sort. The troubles in China also caused a very unsettled feeling at one time, through the fear that they might lead to some serious rupture among the European Powers; but happily this uneasiness was soon dispelled, and a mutual understanding was arrived at between the different governments. Requirements for war materials and ammunition for Great Britain and other nations have given an increased fillip to these branches of trade, and large quantities of metal have been used in this direction.

The elections in Great Britain and in America did not disturb trade to any appreciable extent, because the general feeling on both sides was that the parties in power would, as proved to be the case, be again returned to office. Dearness

of fuel in every producing center was a disturbing factor, and it caused most manufacturers to work at a much smaller profit than was satisfactory, and although the volume of business throughout the year was exceptionally great, it did not bring with it that feeling of security and contentment which should accompany good trade. Taking all points into consideration, however, and remembering the troubles which have so narrowly been avoided in all parts of the globe, the year 1900 will stand out in the annals of the trade of this country as a satisfactory one.

January commenced with a visible supply of 22,817 tons copper, and the cash and three months value was £70. Consumers were buying freely, but only for their immediate requirements, although the demand on this side was good, as it was on the Continent and in America. From this point values improved to £71 18s. 9d. for cash, while forward metal only rose to £71 7s. 6d. At this level very unfavorable news from the seat of war, caused a break in prices to £70 7s. 6d. cash and £69 8s. 9d. three months.

February came in with an upward move, owing to the statistics, which were made to look more favorable by shipments from English stocks in America, and the stock of the world was given at 21,327 tons. Bears got frightened and paid up to £72 2s. 6d. for spot and £70 17s. 6d. for forward prompts. Consumers then followed, and on the report of further consolidation of American interests there was fresh activity and values were run up to £74 17s. 6d. for near prompts and £73 10s. for forward; but it becoming known that the Americans at this time were making cheap offers on the Continent, the speculative market again eased off, and this was helped by the publication of statistics at the commencement of March, which showed a visible supply of 22,982 tons, or an increase for the month of nearly 1,700 tons. Standard copper declined to £74 7s. 6d. for cash and £73, three months, but the scarcity of warrants resulted in a bear scare and values were quickly rushed up to £79 15s. for cash, which price had not been touched for a considerable time, although stuff for delivery in three months was only worth about £5 per ton below cash warrants. All descriptions of copper were being hurriedly put into warehouse to help the sellers of shorts, who were in a corner. The price of refined copper suffered, and this class of copper was being delivered against standard contracts. During this period advices from America were very good, and this helped to frighten operators on this side. When the most urgent needs had been satisfied, values dwindled to £77, cash, and £74 5s., three months, but the trade of the country was good, and before the month was out a rally had taken place, and cash closed at £78 2s. 6d. and three months at £77 8s. 9d. April statistics showed another increase of 1,650 tons in the visible supply, which, when the month opened, stood at 24,632 tons. This feature rather deterred speculators from further commitments, but at this period a large business was doing in the copper share market, where the outside public were being attracted by the excellent returns and dividends which were published by the different producing companies. Consequently, bears of shares rushed in to cover. Standard copper was firm at the commencement in the region of £79 for spot and £77 10s., three months, but a setback occurred owing to large deliveries of English copper into warehouse, which material was de-

liverable against speculative copper, and values suffered considerably, falling to £77 2s. 6d. spot and £75 12s. 6d. forward. The English Government at this time gave out good orders, but the outside trade was slack. May began with the visible supply standing at 27,475 tons, a further increase on the previous month of over 1,800 tons, and this naturally gave the bears further courage, despite the severe squeezes that they had received of late, and they were able to depress prices from £76 17s. 6d. cash and £76 2s. 6d. three months to £71 for cash and £70 10s. three months. Refined sorts were being offered at cheap rates, but at the end of the month, with the news of British successes in South Africa, a further upward move commenced, and June saw values at £72 10s. for all positions. At this time we were again treated to that never-failing bull shout of "fire in the Calumet & Hecla Mine"; and these features were good enough to counteract the bad effect which would have been felt from an increase in stocks of over 1,700 tons. Events in China then gave commercial men food for reflection and prices were put down to £71 5s. cash, £71 12s. 6d. three months. When it became known that all the Powers had practically agreed to a concerted action in the Far East confidence was somewhat restored, and this was helped by a recovery in the iron market here and in America, and the reduction in the Bank of England discount rate which was lowered to 3%. Home and Continental consumers took courage and bought somewhat freely, and this had a good effect on the speculative market, so that standard copper recovered to £72 10s. spot, and £72 2s. 6d. three months, but this level was not maintained, and before the month was out there was a decline to £71 15s. cash, £71 17s. 6d. three months, being a recovery of about 20s. per ton from the lowest.

July started with statistics showing practically no change for the past month, and this had a good effect. Consumers also were buying with more freedom, and good orders were being placed for cable work and warlike stores. Prices of copper were moved upward and touched £73 12s. 6d. cash, and £73 17s. 6d. three months, the month closing slightly easier at £73 cash and £73 5s. three months.

August statistics showed a decrease of 21,300 tons, and the Amalgamated interests again took a prominent share in the market; outside operators rushed in and helped to run values, and cash touched £74 10s., while three months rose to £74 17s. 6d. When this level was reached the mid-monthly figures were published, and showing as they did, a large and unexpected increase, they caused a drop in prices, and operators for the rise got disheartened and began to sell freely, putting values down to £72 2s. 6d. cash, which drop for the time being helped to choke off the regular consumers.

Statistics published at the beginning of September showed an increase in the visible supply of about 1,250 tons, which fact, together with the good trade which was being done on all sides, caused a firmer tone, and values responded by improving to £73 17s. 6d. cash and £74 10s. three months. This advance, however, was brought to an end by the general election in the country and the tightness in the money market on the Continent, and to a somewhat lesser extent in this country. India sent a few good orders at the time, and the Government

also placed fair lines. Before the month was out cash and three months' metal had declined to the region of £72 cash, but just at the close of the month American operators supported and improved values to £72 12s. 6d. cash and £73 2s. 6d. three months.

October started with a decrease in visible supplies, which then stood at 29,133 tons, but the business through the whole month was dull and the trading was below the average. The elections in England and in America caused people to look on for a time so as to see what the possible outcome would be. Consumption remained good, but America was a free seller and took manufacturers' orders at rather cut prices. The public also shirked continuing their commitments, owing to the increase in the contango and closed out their holdings when these prompts fell due. This caused a shrinkage in values to £71 11s. 3d. cash, £72 5s. three months. Toward the end of the month America sent over very strong reports and advices said that the Calumet & Hecla Co., and many of the leading producers had sold out for the year; this caused a slight revival, and the close of the month saw an improvement to about £72 7s. 6d. cash, £73 three months.

Statistics published at the commencement of November showed the visible supply at 28,812 tons, and cash was worth £72, with three months at £72 10s. On the re-election of McKinley to the Presidency of the United States a little burst of speculation was noticed, driving the price of standard copper to £73 5s. cash and £73 15s. three months, but when the buying was completed values again settled down in the neighborhood of £72 10s. cash.

December opened with the visible supply standing at 29,222 tons, being an increase of about 500 tons; and prices came down, being influenced by liquidation of holding of copper shares and the depression in stock exchange circles. The year closed with the quotations for standard copper standing at £73 for spot, and £73 10s. for three months.

Progress in the Metallurgy of Copper.

The following notes on the progress in the metallurgy of copper during 1900 have been abstracted chiefly from the technical literature of the year, although considerable information and criticism has been obtained by direct correspondence.

New Smelting Plants.—Two new smelting plants have been erected in British Columbia in 1900, having the following principal details of construction. The plant of the Granby Consolidated Mining & Smelting Co. at Grand Forks consists of two double-decked, steel-jacketed furnaces 44×160 in. section at the tuyeres with a height to charging floor of 14 ft. and a 150-ft stack. The jackets extend to within 18 in. of the charge floor. The lower section is in three divisions, 7·5 ft. high, while the upper is in two divisions and of 2·5 ft. height. The bottom of the furnace is movable and supported on a cast-iron bed-plate set on eight jack screws. Furnace No. 1 was blown in August 21, 1900, followed by Furnace No. 2 on October 13. The combined capacity is practically 600 tons per 24 hours. This large capacity is due to the size of the furnace and to the

self-fluxing character of the ore, which assays 2 to 3% Cu as chalcopyrite, a small amount of pyrite, 4·5 to 5·5% S, 40% SiO_2, 26% FeO and 19% CaO. The iron occurs mainly as magnetite with a small amount of hematite. The mines at Phœnix supply 600 tons of ore daily. Two trains of 10 cars each are dumped in one hour. The ores are lotted in the bins—8 to 10 carloads forming a lot—and small mine cars of 1-ton capacity convey the ore that has been removed from the bottom of the bin to the sampling works where it is crushed by a No. 5 Gates crusher. The crushed product is conveyed by a bucket elevator to the top of the sampling mill 65 ft. in height. It is here passed over a 5-ft. Snyder automatic sampler which removes a 15% sample of the product for fine crushing and assaying. The bulk of the ore passes from the sampler to a revolving iron spout which distributes the crushed ore to another series of bins where it is stored for direct furnace treatment. The matte averaging 50% Cu is shipped to Eastern works for refining. The plant is operated by electricity generated by water power of 45-ft. fall equaling at all times 1,200 H.P. An important feature of the equipment is the mechanical handling of the ore from the time it arrives from the mine until it is deposited as granulated slag on the dump, including a mechanical charger for the furnaces. Two additional furnaces 44×160 in. and a matte converting plant have been ordered for construction during 1901.

The British Columbia Copper Co. erected a smelter between Greenwood and Anaconda, 2·5 miles from the Mother Lode mine. Water power at 115 ft. head is supplied by an 8-in. pipe line 2,600 ft. long from a dam across Copper Creek. The ores are carried by rail from the ore bins of 3,000 tons capacity to the upper floor of the sampling mill at 124 ft. elevation, which has a capacity of 500 tons in 12 hours. From the sampling mill ore bins the ores are removed by buggy to 12 smelter-mixture bins each of 500 tons capacity and supplied with outlet gates at the bottom to feed the ore by gravity into the buggies which carry it to the furnace charging floor. The ore bins have two tracks above them and the ores may be dumped without sampling, which will simplify the handling when the different character of the ores from the various stopes are known and the material is crushed in the mine. The coke and coal storage is on the same level as the ore bins. The furnace is 42×150 in. section at tuyeres level and has 10 tuyeres 3·5 in. diameter on each side. The down-take from the furnace removes the gases at a distance of 12 ft. above the feed floor, thence up 15 ft. and finally down to the main flue 12×14 ft., which carries the gases 620 ft. to a temporary steel stack 6·5 ft. diameter and 90 ft. high, giving an effective draft height of 190 ft. above the furnace floor. The large size of the present flue is to admit of its use for five additional furnaces and a converter plant. The Standard Copper Co. is erecting a pyritic smelter on Boundary Creek, near Greenwood.

At Nacosari, Mexico, the Moctezuma Copper Co. has erected a new plant to treat the siliceous ores from the Pilares mine. The coarse concentrates forming about 40% of the product are smelted direct while the remaining fine material is first briquetted with 5% clay. Two modern elliptical wrought-iron jacketed furnaces each of 150 tons capacity have been constructed, with a section at the tuyeres of 42×120 in. and an attached tipping well. Two stands of trough

converters each 6·66×9 ft. are in place. The vessels are lined with lean gold and silver siliceous ores having clay as a binder. The low-grade matte requires a ton of lining in making a ton of copper; in fact the lining may be considered a part of the charge. The converter bars are shipped to New York for refining. The central station power is generated by gas engines run by producer gas from hard and soft coal. The engines are belted to generators and the combined current converted to motors at convenient points.

Matte Smelting in Colorado.—The treatment of refractory ores by matting is accomplished at Florence and Golden, where under the supervision of F. R. Carpenter plants have been erected. At Florence the Rocky Mountain Smelting Co. has two large matting furnaces 3×15 ft. section at tuyeres with 15 tuyeres on each side for smelting Cripple Creek ores with addition of dolomitic limestone, pyritic and copper ores. Each furnace treats 250 tons of charge per 24 hours. The construction of a refinery to produce anode copper and doré bullion is contemplated. At Golden the smelter of the Clear Creek Mining & Reduction Co. is 3×16 ft. at the tuyeres, and designed to treat the low-grade refractory ores of Gilpin, Clear Creek and Boulder counties. The Buena Vista Smelting & Refining Co.'s plant at Buena Vista, Colo., is being rebuilt and will consist of 3×16 ft. furnaces similar to those at Golden. The plant will treat ores from the Mary Murphy and other mines, as well as pyritic ores from Leadville. For additional information reference should be made to the special article on "Pyritic Smelting," which is given later in this section.

Smelting at Mt. Lyell, Tasmania.—The Mt. Lyell Co.'s No. 2 smeltery consisting of five furnaces, was completed in 1899, and with the No. 1 works, gives a total of 11 furnaces and a converting plant. The close proximity of limestone and silica deposits suitable for flux, which can be quarried very cheaply, makes the position of the smelting works ideal. The only disadvantage of location is that the ore has to be taken over a precipitous spur to the reduction works located on the east bank of the Queen River. The ore wagons are handled by a bank engine on the top of the spur, having two tail ropes on either side. Four wagons are taken at a time and about 1,000 tons per day are transported 1·5 miles. The bank engine is of the differential type with two drums, one of 14 ft. and one of 9·5 ft. diameter. A load is brought from the mines as follows: The bank engine starts the wagons from below, and after hauling them a third of the distance, the weight of the wagons on the longer grade acting through the larger drum pulls the load up to shorter grade. This self-acting system is controlled by compressed air and two compound lever brakes. From the bottom of the hauling line the wagons are transported by rail to the reduction works, where eight cars at a time are weighed on a 75-ton scale. The second method of transportation is by the Otto double-system aërial ropeway, consisting of a heavy fixed bearing rope and a light motor rope with automatic attachment and detachment of buckets. The line extends 1·25 miles from the mine to the central station, thence branches 300 ft. to No. 1 plant and 960 ft. to No. 2. The buckets weigh 580 lb. empty and about 1,700 lb. full. Eighty buckets are delivered per hour, equaling 950 tons per 20 hours.

H. J. Daly describes* the smelting operations as follows: The total weight of the smelting charge is 3,300 lb. of which the coke comprises 1·8 to 2·4%. The ore is essentially iron and sulphur, the gangue rarely exceeding 15%. At the No. 1 plant the capacity per furnace day, in tons, is: Ore, 86·72; first matte, 18·52; quartz, 32·48; limestone, 20·26; slag, 15·71; coke, 5·18; flue-dust, 1·33; converter slag, 3·45; total, 183·65 tons. The working costs per ton of ore of producing blister copper are officially stated as follows: Mining, 2s. 11·76d.; removal of overburden, 2s.; smelting, 15s. 10·70d.; converting, 2s. 2·30d.; total, £1 3s. 0·76d. The blast furnaces of No. 1 plant are 40×168 in. area at the tuyeres. The No. 2 furnaces are 42×210 in. Height from tapping to feed floor, 20 ft. No. 1 plant has six No. 7 Root blowers, No. 2 has five No. 8 blowers. Each system is operated by separate engines. The cold air from the blowers is passed through hot blast stoves where it attains a temperature of 600°F., an advantage as it allows the heat of a fuel cheaper than coke to be carried into the furnaces, and at the same time increases the oxidizing power of the blast. Slag and matte flow into the forehearth in a continuous stream through the sump which is trapped to prevent the escape of the blast. The forehearth 44×62 in. and 26 in. deep is of sheet-iron lined with fire brick and protected by water-cooled coils between lining and sides. It runs on a track under the spout of the sump. From time to time the heavier matte is tapped from the bottom into pots, while the lighter slag flows through a spout in the top corner to a smaller forehearth and from this into a drain, where it is granulated and removed by the overflow water from the jackets. The first matte, averaging 22% Cu, is crushed and sent to No. 1 plant, where it is concentrated to "converter matte," containing from 50 to 55% Cu. This is treated in a Stahlman converter, the lining of which is a mixture of clay and quartz, lasting eight or nine blows, equal to 15 to 20 hours. The metal from the converter is cast into 200-lb. ingots which are dumped into the water bosh while still hot. The amount of metal turned out per blow ranges from 4 bars in a newly lined converter to 21 bars in an old one, the average about 12. The total time of treatment from ore to blister copper, eliminating times of cooling and transportation, is about 5 hours. From 40,625 tons of matte treated at the reduction works up to March 31, 1900, 20,597 tons of blister copper were produced of an average assay value of 98·81% Cu, 95·58 oz. silver, 3·88 oz. gold per ton.

The following typical analysis of the copper produced at the works:

	%		%
Copper	98·79000	Iron	0·04320
Silver	0·15280	Alumina (from adhering slag)	0·00825
Gold	0·01220	Silica (from slag)	0·05600
Lead	0·02418	Sulphur	0·05600
Antimony	0·00540	Loss undetermined (nickel, cobalt, oxygen, etc.)	0·08638
Selenium and tellurium	0·00610		
Arsenic	0·00096	Total	99·24147
Bismuth	Trace.		

To illustrate the converter process, the results for the last three semesters, have been tabulated as follows:

* A paper read before the Institution of Mining and Metallurgy. London, Dec. 19, 1900.

Six Months to Period Ending:	Converter Matte Treated.				Blister Copper Produced.			
	Tons.	Assay Value.			Tons.	Containing.		
		Copper	Silver.	Gold.		Copper	Silver.	Gold.
		%	Oz.	Oz.		Tons.	Oz.	Oz.
March 31, 1899....	5,357	55·49	63·67	2·263	2,858	2,823	336,053	11,970
Sept. 30, 1899.....	9,192	51·28	43·83	1·550	4,592	4,537	388,165	13,642
March 31, 1900....	9,869	50·93	41·01	1·503	4,797	4,742	387,490	14,605

The flue-dust is collected and formed into briquettes previous to the treatment in a reverberatory furnace, the product being returned to the blast furnace. The quantity of blast-furnace flue-dust collected equals 4% of the crude ore smelted and assays 4·7% Cu, 3·5 oz. silver, and 0·22 oz. gold per ton. The Mount Lyell Mining & Railway Co., Ltd., purchases siliceous ores from neighboring mines. The main pyrite body of the Mount Lyell mine has a distinct value as a metallurgical fuel; and therefore the company is likely to encourage outside mines either to send their crude ore direct to the smelters or to concentrate the lower grade bodies of schist containing chalcopyrite in order to obtain a profitable product. The smelting works are connected by railway to the company's wharf at Strahan, 22 miles away.

Mechanical Charging.—The copper blast furnaces at the Granby Consolidated Mining and Smelting Co., at Grand Forks, B. C., have been equipped with a mechanical charging device that has been in successful operation since the furnaces were blown in. At this plant the furnaces are run with a hot top in order to burn off as much sulphur as possible and the ordinary method of charging by hand required 4 men at each furnace working at 8-hour shifts, equaling 12 men per 24 hours to charge 320 tons of material. To obviate this expensive and laborious task Mr. A. B. W. Hodges has designed and constructed a self-dumping iron car of the same length as the furnace. The car is divided into two longitudinal compartments by a partition, the cross-section of the car resembling the letter **W**. The two middle plates are hinged at the top and drop toward the middle, thereby dumping the charge. Each division holds 2,000 lb. of ore, together with the requisite amount of coke (11%) which is first charged in the bottom. The car is operated by a 0·8625-in. wire cable connected to each end of the car, and passed over a drum which is operated by a 15-H.P. induction motor attached to a tight and loose pulley. The car track over the top of the furnaces is of 75-lb. rails and 6-ft. gauge. The car is dumped at whatever part of either furnace desired and, when empty, is returned down an incline to the end of the furnace room, passing 4 ft. beneath the floor, which has two slots 20 in. wide and of the same length as the car. The fuel and ore are shoveled into the car through these slots, adding first the requisite amount of coke, followed by the ore conveyed by barrows from the different bins. It is stated that this device charges the furnace very uniformly.

Briquetting Fine Ore.—The many advantages of transforming fine ore and mattes into briquettes before treatment in the blast furnace has led to renewed use of presses for this purpose and many old dumps of fine ore, flue-dust, etc., carrying from 3 to 6% Cu are now being briquetted and treated with profit. Briquetting the fine material increases the capacity of the furnace from 10 to 20 per cent.

and saves time and labor in barring down accretions which have a lessened tendency to form when the furnace charge contains but a small amount of fine material. In addition, there is a reduction in the amount of flue-dust formed and a consequent saving in values which were formerly lost in the flue-dust. At first, vertical or horizontal plunger presses were used, similar to those for making pressed clay bricks, but without success, as pressure alone would not bind the material. Later milk of lime or other binder was thoroughly incorporated with the fine material before applying the pressure and a compact product was formed. Among the various types of machines used for briquetting fines the improved White mineral press has given general satisfaction. The apparatus is in two parts, a preliminary mixer and the mill and press itself; the latter has a chasing mill with two large rollers and one side of the bottom of the pan is cut out so as to admit a circular disc with holes or molds, whose center is outside the rim of the pan and whose top surface is level with the bottom. This disc, by its partial rotation, serves to remove the mixed material which is then pressed into its final form by plungers operating outside of the pan when the disc is at rest. A 35-H.P. machine of this type, including the preliminary mixer, has a capacity per minute of 80 briquettes 2×4·5 in. in size. When the material is handled automatically by carrier belt the cost of briquetting, including repairs, power, labor and binding agent, is stated to be 62·5c. per ton. An illustrated description* of this press is given in the reference named below.

Blast Heating.—There has been considerable discussion of the advantages and disadvantages of heating the blast for furnaces treating copper ores, and under the caption "Recent Improvements in Lead Smelting," given later in this volume, are several notes referring to blast furnace practice for smelting copper ores. One of the recent methods designed to heat the blast is being constructed at the new smelter of the Ludwig Mond Co., Victoria mines, Ontario. An iron flue to convey the furnace gases to the stack has an air conduit constructed within it at the top. The air for the furnace in passing through this conduit becomes heated by the heat transmitted from the hot gases in their passage from the furnace top to the stack.

It is stated that the use of heated blast in the 200-ton matting furnaces of the United Verde Co. at Jerome, Ariz., has reduced the fuel consumption to 200 lb. or less per ton of ore. Other details of heating the blast, including the Bretherton hot-air attachment, are given in the special article on "Pyritic Smelting," elsewhere in this section.

Recharging Foul Slag.—The practice at a large Western copper smelting plant is to recharge foul slag while it is still molten, the mass from the slag pot being held together by the solidified crust only. The results obtained in this way are stated to be quite as satisfactory as when the slag has been charged in small solid pieces.

Tilting Forehearth.—The Gates Iron Works, of Chicago, Ill., has constructed a tilting forehearth† for copper furnaces. The hearth is of large capacity and constructed of heavy steel plates mounted on steel rails, operating on four truck wheels which are attached to heavy steel axles, with bearings mounted on massive

* *Engineering and Mining Journal*, March 2, 1901. † *Ibid.*, Nov. 24, 1900.

cast-iron pedestals. Two of the wheels are grooved to receive the rail, thus acting as a guide. The tilting mechanism consists of a rack engaging a segmental gear attached to the base of the cradle and operated by a hydraulic cylinder.

Slag Conveyor.—The new slag conveyor at the Lake Superior Smelting Works, Dollar Bay, Mich., consists of four towers of from 23 to 28 ft. in height, each carrying two sheaves for the endless cable upon which the slag pots are hung. The towers are built of 60-lb. T rails with a lateral rail foundation to which the uprights are bolted. In this way the towers are readily moved. The steel cable is 1·25 in. in diameter and 1,175 ft. long and passes around horizontal sheaves 4 ft. in diameter, one directly in front of the tap hole of the blast furnace and the other at the eastern extremity of the runway. The operating power is communicated to the inner sheave. Ordinary slag pots of 300-lb. capacity are used, having a bale attached to the lugs, and a simple automatic device is provided to dump them. When filled with molten slag each pot is carried to the cable by a traveler and transferred directly without loss of time. Two men on each shift are required to operate the conveyor, where heretofore five men on each shift have been needed to remove the slag by hand.

Cost of Smelting in Utah.—Richard H. Terhune* gives the following estimate of the cost of smelting ore at the Highland Boy smelter, Utah, not including the handling and moving of raw and roasted ore or general expenses; these items, however, are very low. Under the above conditions the cost per ton of smelting Highland Boy ore averaging 8% Cu to blister copper (99·2% Cu) is: Roasting, $0·40; fusing the roasted product, $1; bessemerizing 160 lb. of copper at an average of $0·006 per lb., $0·96; total, $2·36.

Wet Extraction of Copper from Ores.—Caleb G. Collins has patented three processes for the extraction of copper and zinc from finely divided ores by treatment with a solution of sodium sulphate and bisulphate (niter cake)† with a solution of sodium sulphate, hydrochloric and sulphuric acid‡ and with a solution of sodium sulphate and bisulphate, sodium chloride and hydrochloric acid.§ The dissolved metals may be subsequently precipitated by electrolytic methods.

Bessemerizing Copper Matte.—According to Prof. Henry M. Howe, the David selecteur process, which has been described in THE MINERAL INDUSTRY, Vol. VIII., p. 183, also *Annales des Mines,* XIII., p. 621, is not likely to find a wide application, as most copper mattes contain so much silver that they are in any event electrolyzed to recover the metal, and if the quantity of arsenic or antimony be moderate, these impurities are removed completely and readily in the common converter process and electrolysis jointly. In this case, therefore, there is nothing to be gained by the complications which M. David's procedure introduces. But in case of mattes which contain more arsenic and antimony than can be readily removed in the common converter, so that the copper made from them would be inconveniently impure for electrolyzing, M. David's plan may merit careful investigation, especially if there be so little silver present that its recovery is not in itself sufficient motive for electrolyzing the copper. In short, the process may be found useful in treating very impure mattes which contain very little silver.

* Private communication, Feb. 12, 1900.
† United States Patent No. 659,338, Oct. 30, 1900.
‡ United States Patent No. 659,339, Oct. 30, 1900.
§ United States Patent No. 659,340, Oct. 30, 1900.

In connection with the David selecteur process, F. R. Carpenter* proposes its use for the treatment of copper mattes that are very rich in gold; material that is not desired by electrolytic copper refiners. The first metallic copper formed carrying all the gold and most of the silver can be caught and tapped separately and the remaining high-grade copper matte, having had removed from it most of its gold and much of its silver can then be blown to blister copper and sold direct to the refiners. The copper bottom is granulated, oxidized and cast back into matte, thus effecting a second "selecting" similar in all respects to the first. The selecting process requires the presence of a certain amount of lead in the copper matte. The lead is concentrated in the first bottom and comprises a large percentage of it. In the second selecting, the percentage is enriched so greatly that the resultant bottom may be at once cupelled—often without the addition of extra lead. In fact the first bottom may be cupelled at once provided lead is added, the coppery litharge produced being even more fusible than the purer litharge of ordinary methods. In practice, 6 parts of lead to 1 of copper give very satisfactory results. The final coppery litharge can be treated by the lead smelter by adding it direct to the ore charge, the lead going to the bottom and the copper to the matte. Equally good results, with much less trouble, can be obtained by returning the first bottoms to a reverberatory furnace with the addition of sulphide material and re-treating them until they are sufficiently reduced in size for final cupellation with metallic lead. The resultant cupriferous litharge is reduced to metallic lead and matte by treatment in a small reverberatory or "softening" furnace with galena or iron pyrites. The lead may be used again and the matte returned to the ore smelting process.

The Garretson Furnace.—The Alpha Mining and Copper Smelting Co. has been organized at Cincinnati, Ohio, with a capital stock of $500,000, to erect and operate the patented Garretson pyritic furnace for roasting, smelting and converting copper sulphide ore. This process has been referred to in THE MINERAL INDUSTRY, Vol. VII., p. 225, and while endorsed by a few prominent metallurgists it is criticised by others for the attempt to combine in one furnace the operations of roasting, smelting and converting, each requiring widely different conditions for successful working. The results of the practical application of the process are awaited with considerable interest.

Copper and Its Alloys at the Paris Exposition.—The data in the tables on pages 221 and 222 have been kindly furnished by Prof. Henry M. Howe from his report to the United States Government on the Paris Exposition of 1900.

Uses.—One of the new uses to which copper has been successfully applied is the coating of railroad passenger cars forming a substitute for paint and varnish. Twenty-nine new cars for the Erie Railroad have recently been sheathed. The sheet copper used on the sides is 0·012 in. thick and fastened to the wood by screws. When in place the metal is washed with a weak acid solution to secure a uniform color and finished with a coat of lacquer. The first cost is greater than that of painting, but the final saving is considerable.

Anti-friction Alloys.—Robert Job† presents the results of an investigation on

* A paper read before the American Institute of Mining Engineers, August, 1900.
†*Journal of the Franklin Institute*, June, 1900.

the causes of hot boxes in railway service due to defects in the bearings. The physical condition and structure of the alloy exert a marked influence on the efficiency of the metal in service, a fact that was formerly overlooked. The old copper-tin alloy of 7 to 1 was found to be inferior, and the copper-tin-lead composition was gradually introduced, at first with phosphorus and later with a diminished amount for deoxidizing purposes only. The efficiency of the copper-tin-lead alloy, it was found, increased with the proportion of lead present, limited by the maintenance of sufficient strength and a fairly high melting point

CHEMICAL COMPOSITION OF COPPER, ALLOYS AND MATTES.

Number.	Maker (or authority), Country, etc.	Class. Copper and Matte.	Composition. Cu.	Fe.	Zn Co Ni.	Ag.	Sn.	Pb.
1	Compagnie du Boleo, Mexico.	Electrolytic copper	99·894	0·042	0·006	*Nil.*	*Nil.*	*Nil.*
2		Baltimore cathode copper	99·875	0·031	0·057	*Nil.*	*Nil.*	Trace
3		Orford cathode copper	99·802	0·013	0·078	Trace	*Nil.*	Trace
4		Lake Superior copper	99·770	0·024	0·047	0·030	*Nil.*	*Nil.*
5		Corocoro copper	99·766	0·050	0·070	0·004	*Nil.*	*Nil.*
6		Boleo copper	99·749	0·024	0·075	0·028	*Nil.*	0·002
					Zn.	Ni.	Co.	
7		Boleo black copper	96·250	0·837	0·422	0·230	0·325	0·422
					Mn.	Ag.	Ni & Co.	
8		Boleo matte	63·86	10·02	2·12	0·02	0·49	0·00
		Solders.	Cu.	Zn.	Ag.	Sn.	Total	
9	Gaston Auscher, Nancy, France.	Solder for copper and iron objects	52	48			100	
10		Solder for silver	32·8	46·4	20	0·8	100	

Number.	Maker (or authority), Country, etc.	Class. Copper and Matte.	Composition—*Continued.* As.	Sb.	Bi.	S.	O.	P.	Total
1	Compagnie du Boleo, Mexico.	Electrolytic copper	0·016	0·029	*Nil.*	0·008			
2		Baltimore cathode copper	0·02		*Nil.*	0·024			
3		Orford cathode copper	0·03		*Nil.*	0·079			
4		Lake Superior copper	Trace	Trace	*Nil.*	0·070			
5		Corocoro copper	0·027	0·032	*Nil.*	0·018			
6		Boleo copper	0·005	0·020	*Nil.*	0·016			
7		Boleo black copper		0·013		0·767		0·012	99·278
							SiO_2.	CaO& MgO.	
8		Boleo matte	0·01	0·08	0·14	22·35	0·78	0·08	99·95
		Solders.							
9	Gaston Auscher, Nancy, France.	Solder for copper and iron objects.							
10		Solder for silver							

to prevent fusion. The amount of lead used in best practice is generally 15%. A microscopic study was made of the fractures of a large number of bearings which had run hot on cars and were subsequently removed. Chemical analyses were made at the same time, to determine whether the results were due to an attempt to form impossible alloys or to improper foundry manufacture. The bearings examined varied widely in composition; among others being the old copper-tin alloy of 7 to 1 and the copper and zinc bearing of 35% Zn. The latter alloy gave excellent results as to heating, but was generally condemned on account of its exceedingly rapid wear. Phosphor bronzes were found in moderate amount while the copper-tin-lead alloys averaging 10 to 15% Sn, 5 to 15% Pb, balance copper, were the most numerous. The main causes of ineffi-

ciency were: 1. Segregation of metals. 2. Coarse crystalline structure. 3. Dross or oxidation products and excessive amount of enclosed gas in the metal. The lack of proper lubrication appeared to play a minor part. Segregation in

PHYSICAL PROPERTIES OF NONFERROUS METALS AND ALLOYS.

No.	Maker and Country.	Treatment, Class, etc.	Tenacity, Pounds per square inch.	Elastic Limit Pounds per square inch.	Elongation. %	Elongation. In
		Copper and Brass.				
1	Soc. le Ferro-Nickel, Lizy sur Ourcq, France	Copper, pure (apparently assumed as standard)	31,300 to 32,700	8,500 to 10,000	36to 38	
2		Chrome copper	39,800	17,000	35	
3		Chrome copper	45,500	21,300	25	
4	Elmore's Metall-Actien-Gesellschaft, Schladern am Sieg, Germany	Copper for condenser chamber, Annealed	33,700		43	8 in.
5		Copper for condenser chamber, Unannealed	40,400		30	"
6		"Elmore Process." Annealed	32,000		41	"
7		"Elmore Process." Unannealed	41,500		26	"
8	Felix Hubin, Harfleur, France	Copper, Bright annealed	33,100		41·5	
9		Copper, Bright annealed	32,800		41·4	
10		Copper, Bright annealed	32,000		45·6	
11		Copper, Bright annealed, Powder	32,700		43·5	
12		Copper, Annealed, Boxes	32,400		44	
13		Brass	44,600		42	
14		Brass, Caps	45,500		58·2	
15		Brass, Miscellaneous uses	45,200		64·5	
16		Brass, Tubes	44,900		62·5	
17		Brass, Hollow plugs and fuse caps	44,900		64·6	
		Brass Tubes, Seamless.				
18	Felix Hubin, Harfleur, France	Bursting test (Eclatement) Tubes for condensers	40,100			
19		Bursting test (Eclatement) Tubes for boilers	45,600			
		Copper Tubes, Seamless, Superior Quality.				
20	Felix Hubin, Harfleur, France	Bursting test (Eclatement) Annealed test pieces	32,000	6,400		
21		Tensile test.. Annealed test pieces	32,400	6,700	42·5	
22		Tensile test.. Annealed test pieces	35,400	24,200	31	

many cases was due to improper proportion of constituent metals; particularly noticeable in the copper-tin-lead alloys in which an excessive amount of lead had been introduced, which resulted in the liquation of a portion of the lead and often in the separation of a part of the copper as "copper spots" of relatively high heating capacity that ultimately caused a hot box.

The Manufacture of Blue Vitriol.—Hofmann's method for the manufacture of blue vitriol, which was described in detail in THE MINERAL INDUSTRY, Vol. VIII., has been modified and improved both as regards construction of apparatus and as to handling of materials. At the Argentine plant of the American Smelting & Refining Co., where this process is employed, the pulverized roasted copper matte is dissolved in eight agitating tanks, each measuring 12 ft. in diameter and 6 ft. deep. Below these two tanks are two cast-iron pressure tanks, the body of which is constructed in two cylindrical sections 4 ft. long by 4 ft. 6 in. in diameter, the bottom being of a spherical section of 2 ft. 3 in. radius, and the top rounding upward to a height 9 in. above the rim. The sections are tightly flanged with a rubber gasket between. The apparatus in which the refining of the solution is done has also been improved by replacing the iron framework and the towers with vats of California redwood, which is an excellent material to resist the action of hot cupric sulphate solutions. The new towers are 9 ft.

in diameter and 6 ft. high and are constructed of 4-in. material well hooped with round iron. The towers are firmly fastened to a strong wooden trestle which in turn is anchored to a concrete foundation. The lead steam coil formerly used has been discarded and the heating is now accomplished by direct steam. The perforated cones, of which there were three in each tower for the distribution of the compressed air throughout the solution, have been replaced by a sufficiently large perforated pipe.

Progress in the Electrolytic Refining of Argentiferous Copper.

By Titus Ulke.

General Review.—The present status of the electrolytic refining industry in the United States and its great economic importance can perhaps best be appreciated by a study of the subjoined carefully compiled table. Owing to the policy of secrecy still maintained by a few of the refining companies and their refusal to furnish the required data for publication, some of the items in the table necessarily had to be estimated as in previous years. The estimates given, however, are believed to be quite close.

From the figures in the table it follows that nearly 16,000 H.P. are now consumed in the United States alone for the electrolytic refining of argentiferous copper. With this power about 580 tons refined copper are produced daily and a by-product recovered containing 51,800 oz. silver and 481 oz. gold. This amounts to an annual production of 211,700 tons copper, valued at not less than $67,000,000, besides 18,907,000 oz. silver and 175,565 oz. gold, respectively, valued at nearly $11,611,000 and $3,629,000. More than two-thirds of the entire copper production of the United States is now refined electrolytically.

Ten copper refineries were operated in this country in 1900, the electrolytic works of the Bridgeport Copper Co. at Bridgeport, Conn., and of the New England Electrolytic Copper Co. at Central Falls, R. I., having been closed down.

With reference to the source of the material treated, the quantity of Lake Superior "mineral" (*i.e.*, native copper ore averaging say 80% copper) refined electrolytically is increasing. The Calumet & Hecla Co. is erecting a new tank house at its Buffalo Smelting Works, which will enable it to increase the daily output at its Buffalo works from 6 to about 40 tons of electrolytic copper. The crude "mineral" carries from 17 to 30 oz. silver per ton. A low current density is used in its refining, as the stocks of copper on hand at the Buffalo works considerably exceed the refining capacity of the electrolytic plant and it is stated that the interest on the same is of minor importance; furthermore, the cost of the power required quadruples with the doubling of the current density.

Considerable argentiferous material from foreign countries, notably Mexico, Canada, Spain, Tasmania, and Japan has been shipped to the United States and there refined.

Argentiferous copper has been obtained from Mexico, Tasmania and Japan; matte containing both nickel and copper or copper alone from Canada; and silver and copper bearing pyrites, whose silver and copper contents in most cases eventually reach the electrolytic refineries, from Canada and Spain.

ELECTROLYTIC COPPER REFINERIES IN THE UNITED STATES OPERATED IN 1900.

No.	Name of Company and Location of Works.	Kind of Material Chiefly Treated.	Approximate Daily Copper Output in Tons (2,000 lb.)	Number and Capacity of Generators. Kw. = Kilowatts.	No. of Tanks in Refinery.	Arrangement of Electrodes.	Approximate Daily Output of Gold and Silver from Slimes.
1...	Raritan Copper Works (Lewisohn Bros.), Perth Amboy, N. J.	Mount Lyell, United Verde, Hauauer, Boston and Montana, and miscellaneous anodes and pig copper.	150 to 200 (Cap. 200)	Five @ 600 Kw.	1,600	Multiple.	8,000 to 10,000 oz. Ag. 175 to 200 oz. Au.
2...	Anaconda Mining Co., Anaconda, Mont.	Anaconda anodes.	100 (Cap. 150)	Six @ 270 Kw. Two @ 300 Kw. One @ 200 Kw.	1,430	Multiple.	8,000 oz. Ag. 35 oz. Au.
3...	Baltimore Smelting and Rolling Co. (Baltimore Copper Works), Baltimore, Md.	Anaconda anodes and miscellaneous material.	80	Eleven @ 80 Kw.	540	L. p. series. S. p. multi.	6,400 oz. Ag. 28 oz. Au.
4...	Boston and Montana Cons. Copper and Silver Mining Co., Great Falls, Mont.	Boston and Montana anodes and miscellaneous material.	60	Two @ 600 Kw.	600	Multiple.	3,960 oz. Ag. 9 oz. Au.
5...	Nichols Chemical Co., Laurel Hill, N. Y.	Mountain Copper and Copper Queen anodes and Canadian and Spanish pyrites cinders.	60	Four @ 200 Kw.	400	Series.	1,000 oz. Ag. 34 oz. Au.
6...	Guggenheim Smelting Co., Perth Amboy, N. J.	Anodes and pig copper from Mexico and Colorado.	50	Three @ 180 Kw.	390	Multiple.	20,000 oz. Ag. 175 oz. Au.
7...	Balbach Smelting and Refining Co., Newark, N. J.	Orford anodes and miscellaneous.	30	Eight @ 75 Kw.	432	Multiple.	2,500 oz. Ag. 13 oz. Au.
8...	Irvington Smelting and Refining Co., Irvington, N. J.	Scrap copper and miscellaneous.	9	Two @ 80 Kw.	180	Multiple.	720 oz. Ag. 2 oz. Au.
9...	Buffalo Smelting Works, Black Rock, N. Y.	Lake Superior, argentiferous native copper "mineral."	6	Two @ 48 Kw.	270	Multiple.	120 oz. Ag. 2 oz. Au.
10...	Chicago Copper Refining Co., Blue Island, Ill.	By-products and miscellaneous pig copper.	5	Two @ 64 Kw.	250	Multiple.	100 oz. Ag. 3 oz. Au.

Several noteworthy improvements in the arrangement and equipment of refining plants are described by Mr. Lawrence Addicks in a separate paper later in this section on "The Raritan Copper Works," to which excellent description the reader is referred. A few additional facts that have come to my notice are given in the following pages.

Ribbed Anodes.—At the Buffalo Smelting Works, the anode plates weigh about 289 lb. each and are cast about 1·625 in. thick at the top, tapering down to 1·375 in. at the bottom, with much thinner anode lugs and three longitudinal strengthening ribs cast in. The ribbed anodes are said to hold together much better than the plain ones.

Stripping Cathodes.—At the Buffalo works the cathode sheets which are used in the commerical tanks to receive the copper deposits are formed by deposition on both sides of copper sheets lightly washed with a dilute solution of iodine in naphtha. The use of an iodine wash instead of tallow to prevent the firm adhesion of the deposited copper to the surfaces avoids the necessity of cleansing those solutions from tallow, ordinarily done by forcing them under inverted dams.

Treating Anode Scrap.—The perforated lead baskets for holding pieces of anode scrap have been very successfully used during the past year. These baskets are in the shape of flattened cylinders, the interior dimensions of which are approximately 6×12 in.×3 ft. deep. In this way two of the baskets are hung in the bath side by side and take the place of a full width anode.

Refining Copper from Impure Solutions.—F. Klepetko and J. T. Morrow have patented a process* of purifying copper from solutions containing copper with antimony as an impurity. The operation consists in introducing wood-tea into the solution and subsequently subjecting the solution to electrolysis, which deposits the copper in a purified state.

Treatment of Impure Solutions.—E. A. Smith† first removes the copper salts (blue vitriol) from the impure electrolyte by crystallization and the iron-salts by progressive shallow evaporation at high temperature and then after cooling adds suitable hyposulphite to remove the antimony and arsenic while retaining the liberated sulphurous acid in solution, and finally dilutes with water, to complete the precipitation of antimony and arsenic. The free acid remaining is returned to the refinery bath.

Refining Copper with Chloride Solutions.—Hoepfner's process still appears to be in the experimental stage. Among several difficulties encountered, the redissolving of the deposited copper by the cupric chloride is not the least. This difficulty is said to be successfully overcome now by using a short cathode and a long carbon anode, and then drawing off the heavier cupric chloride from the bottom of the anode so as to prevent the short cathode from coming into contact with the cupric solution.

Refining Copper with Nitrate Solutions.—According to Dietzel,‡ an electrolytic process for refining fused wastes, containing from 40 to 65% copper, 22 to 50% silver and 5 to 7% gold, has been successfully used for many years at Pforzheim, Germany, where about 60 kg. of the alloy are decomposed per day. A slightly acid solution of copper nitrate is used as electrolyte. At the anode, copper and silver are dissolved, copper is deposited at the cathode, the gold remain undissolved and the silver, which is replaced by copper, is recovered in another tank by a special process. A current density of 150 amperes per sq. m. is employed and a voltage of 2·5 to 3 volts. It is claimed that the cost of the process is covered by the value of the refined copper obtained.

Electrolysis of Solid Cuprous Chloride.—James Douglas, New York, has patented a process§ for electrolyzing solid cuprous chloride and employing the gases evolved in the treatment.

Effect of Arsenic on Copper.—According to E. A. Lewis,‖ the presence of a small amount of arsenic in copper intended for rolling, excepting that for electrical purposes, appears to be a distinct advantage, but nothing is gained by having more than 0·5% present.

* United States Patent No. 657,119, Sept. 4, 1900.
† United States Patent No. 617,886, of 1899.
‡ *Engineering and Mining Journal*, Sept. 2, 1899.
§ United States Patent No. 664,537, January, 1901.
‖ *Chemical News*, Jan. 4, 1901, and *Engineering and Mining Journal*, March 16, 1901.

Effect of Oxygen on Copper.—E. S. Sperry* states that it is customary, in copper refining, to leave a small amount of oxygen in the metal in order to oxidize any traces of bismuth, arsenic or antimony, which have not been entirely removed. As a result, these metals exist in the commercial product as oxides, and not as metals, which would form an alloy with the copper and so injure its quality. In making copper bars for the manufacture of wire of high electrical conductivity and cakes to be rolled into sheet, this practice is without doubt beneficial; but it does not improve the copper for the manufacture of brass or other alloys. Zinc will reduce copper, bismuth, antimony and arsenic oxides and form zinc oxide. If oxygen is present in an excessive quantity, due in most cases to imperfect covering of the melt with charcoal, much zinc oxide is formed, which causes the brass to crack when being rolled into sheets, or brings about the formation of almost infusible "salamanders." Sperry's experiments with leading brands of "Electrolytic" and "Lake" copper, both of which contain an average of about 0·01% O, lead him to the conclusion that the small amount of oxygen in commercial copper cannot, by itself, be considered an injurious impurity and that good sheet brass can be made from copper containing 50 times this quantity.

Methods of Assaying and Analysis.—I have described the modern commercial methods of copper assaying and analysis in the *Engineering and Mining Journal,* December 16, 1899. The details cannot well be abstracted to advantage and reference should be made to the original article which outlines the laboratory work at a modern electrolytic refinery and includes the following determinations:

1. Free acid and blue stone in the electrolyte.
2. Arsenic in the electrolyte.
3. Antimony in the electrolyte.
4. Iron in the electrolyte.
5. Chlorine in the electrolyte.
6. Copper in copper bullion and anodes.
7. Copper in slags.
8. Arsenic in cathodes and wire bars. (Distillation method.)
9. Arsenic in refined copper. (Aller's modification.)
10. Arsenic and antimony in copper bullion. (Knorr's modification.)
11. Gold and silver in copper bullion, anodes and cathodes.
12. Gold and silver in blister and refinery slags.

L. D. Godshall, in a paper on "The Assay of Copper Materials for Gold and Silver,"† discusses the need of a short and, at the same time, exact method for the determination of gold and silver in copper materials, to replace the two general methods now in use.

The usual dry or fire-method, comprising: (1) scorification and cupellation, the former being repeated if the percentage of copper is very high; (2) the assay of all slags and cupels and the addition of the results so obtained to the ordinary assay; and (3) the determination of the copper retained by the silver buttons and deduction of the amount found from the combined weight of the buttons obtained from the assay of the original material, requires too much work.

* A paper read before the American Institute of Mining Engineers, August, 1900. † *Ibid.*, February, 1900.

The wet or combination method, while not involving so much work, requires a longer time, as appears from the following brief description of this method: The material to be assayed is dissolved in nitric acid, the solution is diluted, and the fine undissolved gold is collected by means of lead sulphate formed by the addition of lead acetate and sulphuric acid to the solution. After standing from 12 to 24 hours, the precipitate is filtered off, and the silver in the filtrate is precipitated as a chloride or bromide, and collected by means of lead sulphate or bromide. The solution containing this precipitate in suspension is again allowed to stand until the precipitate has settled. It is then filtered; both precipitates containing the gold and silver are dried, ignited and scorified, either separately or together, and the result is cupelled in the usual way.

In this method, the undissolved gold is naturally in an exceedingly fine state of division; the lead sulphate, though heavy, is a fine precipitate, slow to filter, and unless care is taken, is liable to go through the filter-paper. Again, in case any gold is dissolved, through impurities in the reagents, or from other causes, there are no means of detecting or saving it. In order to overcome the above objections, Godshall proposes to make use of two reactions, namely, the fractional precipitation by means of hydrogen sulphide, and the reaction between precipitated copper sulphide and a soluble salt of silver. The idea is to precipitate just enough copper sulphide to insure the complete precipitation of the silver, and at the same time to collect the very fine undissolved gold, the copper sulphide also reacting upon any gold in solution and rendering it insoluble.

A. R. Ledoux* criticises the above paper and states that the so-called "combination method" has been modified and is now generally practiced as follows: One A. T. of the bar copper borings is dissolved in dilute nitric acid. When solution is complete, the liquid is boiled and then filtered to remove gold. The filtrate is treated with sufficient salt solution to precipitate all the silver, but avoiding any unnecessary excess. The liquid is allowed to stand over night and next morning the silver chloride is collected on a fresh filter, which, together with the paper containing the gold and insoluble matter, is scorified and cupelled. The use of sulphuric acid and lead salts, to entangle the silver chloride and prevent it from passing through the filter, as formerly in vogue, is now generally considered unnecessary. According to Ledoux, if it is not possible to let the silver chloride settle over night, accurate results may be obtained by stirring the liquid vigorously with some form of mechanical stirrer for half an hour or by blowing air through the liquid. It is quite possible to make an accurate assay by this method in three hours. In some cases, noticeably those in which the bar copper is very free from impurities and the gold content small, the correct gold assay may be obtained by parting the bead obtained by this process. In most cases, however, the gold assay so obtained is too low, even though the gold be removed from the liquid by filtration before adding the salt solution. Fresenius and Van Liew ascribe the low results in gold chiefly to the dissolving action of nitrous acid. In order to obtain correct results it is generally necessary to resort to the "all-fire method," which consists in weighing out a number of 0·1 A. T.

* *Engineering and Mining Journal*, Sept. 15, 1900.

portions—usually 10—and scorifying them with lead until most of the copper is removed—then cupelling the lead-buttons either separately or uniting them five and five, rescorifying, and cupelling. As the method involves many scorifications and the use of much test-lead, it is expensive and laborious. The first scorification must be conducted at a high temperature and the operations consume a great deal of time and muffle room. However, in 96 to 98% Cu, containing from 1 to 5 oz. gold per ton, the "all-fire" results will generally be from 0·1 to 0·3 oz. higher than can be obtained by the combination method. Notwithstanding this, as Ledoux states, any method that would give correct gold and silver results on all classes of bar-copper at one operation, and that would avoid the tedious and expensive operations of the all-fire process, would find ready acceptance among assayers. The method described by Dr. Godshall seemed to offer some possibilities in this direction.

Comparative tests made in Ledoux's laboratory, however, indicate that the Godshall method gives good results on silver, but low assays on gold. The figures on gold are about the same as would be obtained by using the "combination-method." Quoting Ledoux: "The new method does not seem to possess any advantage over the 'combination-method' in point of speed. When the silver chloride is stirred well or 'blown down' with air, it can be filtered off as quickly as the sulphide precipitate. On the other hand, the new method requires the use of hydrogen sulphide, which is a noxious and troublesome reagent to handle on a large number of samples at the same time."

W. R. Van Liew, in a valuable article entitled "Causes of Losses of Silver and Gold in Copper Bullion Assaying and a Method for Overcoming Them,"* proposes to improve the standard wet method by keeping the nitric acid solution in dissolving the copper, cold, and eliminating the nitrous acid present without the aid of heat, at the end of the operation of dissolving.

G. T. Dougherty, in discussing the above article,† states that it seems feasible to shorten the time of Van Liew's method greatly by placing the weighed copper borings and nitric acid of the specified dilution in a sufficiently capacious beaker and passing air from a Richard blower, filter pump or aspirator, through the liquid from the very beginning of the process, instead of waiting until all the copper has dissolved, as in Van Liew's method.

Determination of Oxygen in Copper.—L. Archbutt‡ finds that the extreme heat necessary in Blount's method, in which the metal is fused in a stream of hydrogen, and the water produced is absorbed in a weighed sulphuric acid tube, is inconvenient, and that it is quite possible by modifying the original Hampe process to obtain perfectly accurate results. From 30 to 40 g. copper in drillings small enough to pass through a tube 0·125 in. in diameter are freed from grease with ether, dried on the water oven and dessicator and weighed into a special tube of Jena glass, 205 mm. long and 5 mm. in diameter, having its center expanded into a cylindrical bulb 65 mm. long and 31 mm. in diameter. The tube is supported over a flat-flame Bunsen burner in a sheet-iron box, jacketed with

* *Engineering and Mining Journal*, April 21 and 28, 1900. † *Ibid.*, June 23, 1900.
‡ *Analyst*, 1900, 25, 253.

asbestos millboard. The tube is connected with an apparatus for the supply of pure hydrogen, which is passed slowly enough to insure the reduction of any sublimate of arsenic trioxide within the tube. The temperature is raised to a red heat for one hour and the loss in weight of the copper is then ascertained.

Direct Production of Electrolytic Wirebars and Tubes.—It is a well-known fact that copper as usually deposited from an electrolytic bath generally has a crystalline and somewhat porous structure, and consequently must be fused before being rolled and drawn. This fusion allows certain impurities to get into the pure copper, reducing its high conductivity, and for this reason many inventors are seeking to devise an electrolytic process which will deposit the copper in such a condition that it may be taken straight from the depositing bath to the rolling or drawing mills.

E. Emerson has patented a method* of making bars adapted to be drawn into wire directly from the unrefined metal deposited by electrolysis. A special strip of metal is produced by electro-deposition on a cathode, it is then removed and wound spirally on the cathode at right angles to the position occupied at first, the cathode is placed on a cage suspended in a depositing-tank, so as to expose all the surfaces of the strip of metal, and the sectional area of the strip is increased by electro-deposition of the copper on the strip until a bar of sufficient size is produced, which may be rolled or drawn into wire.

S. O. Cowper-Coles, of London, secured a patent† for the electrolytic manufacture of copper wire or strips, by depositing copper in the spaces formed by winding cords or tapes around a mandrel, which is a cathode, and revolving the mandrel rapidly. His United States patent‡ covers a process for the electro-deposition of metal, which consists in passing an electric current from an anode to a cathode through an electrolyte containing the metal to be deposited, at the same time moving the cathode at such a rate of speed that will cause the hydrogen bubbles to be thrown off from the metal deposited on the cathode, and cause such friction between the metal deposited on the cathode and the electrolyte as to yield tough and smooth deposits. E. Emerson discusses this process§ and claims that it lacks novelty substantially for the following reasons: 1. The method exactly as described has been in public use for several years in coating iron rolls with copper. 2. In 1888 Emerson deposited copper strips 0·25 in. thick and over, adapted to be drawn into wire by winding a copper cylinder with strips of rubber and depositing copper in the spaces between the coils of same. 3. Emerson was granted a patent,‖ the claim of which reads as follows: "In an electro-depositing apparatus, a rotary cylindrical cathode, divided by a spiral line on band of insulation, so to form one long strip of depositing surface."

Seamless Tubes of Electrolytically Deposited Copper.—At the Paris Exposition in 1900, the Société Française d'Electro-Métallurgie had a very interesting exhibit of seamless copper tubes, bars, etc., made by the Elmore and Secretan process. One of the tubes exhibited was 10 ft. long by 4 ft. diameter, the thickness of the metal being 0·25 in. In the Elmore and Secretan process, an agate

* United States Patent No. 638,917, Dec. 12, 1899.
† English Patent No. 26,724, 1898.
‡ United States Patent No. 644,029, Feb. 20, 1900.
§ *Engineering and Mining Journal*, April 7, 1900.
‖ United States Patent No. 395,773, Jan. 8, 1889.

burnisher and a slowly rotating steel or brass mandrel is used, except when tubes of special shapes are required, when the mandrel may be made of fusible metal, which can afterward be melted out of the finished tube.

It is still a commonly accepted belief that uniformity in the quality of electrolytic copper in manufactured or partly manufactured form is very difficult of attainment, and that the cost of making good wirebars, tubes, cylinders, etc., by direct electrolytic processes, except in certain special cases, must be lowered before such processes can come into general use.

Casting Machines and Conveyors.—The Walker improved casting apparatus, as used for casting copper, was described and illustrated in THE MINERAL INDUSTRY, Vol. VII., for 1898, having then been in successful operation for about two years. Since then its capacity has been increased, and a brief account of the work now being performed is as follows:

The five machines at the Baltimore Copper Smelting and Rolling Co.'s plant

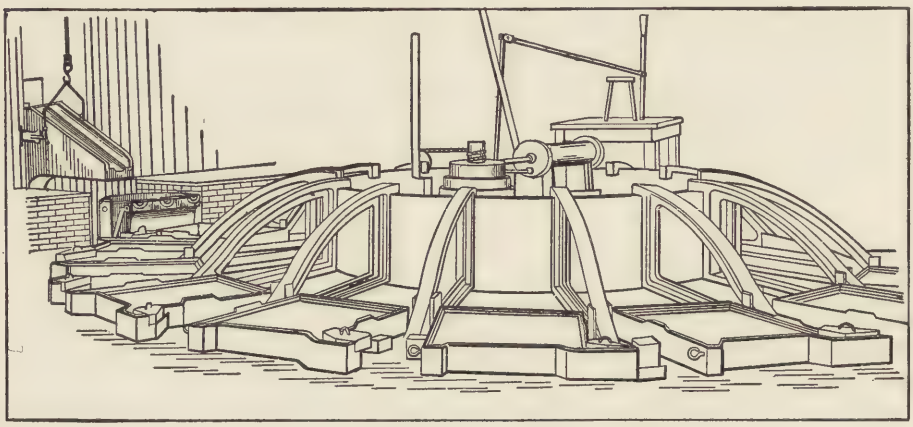


FIG. 1.—THE WALKER ANODE CASTING MACHINE

have been operated continuously, and the output so increased that charges of over 100,000 lb. of wirebars are easily handled. Small ingots are cast even more readily than bars, pouring six at a time from a multiple spout ladle, and the capacity for this work will average about 114,000 lb., the machine casting them at the rate of 27,000 lb. per hour. Larger furnaces are now being built which will have these machines attached, and daily charges of 150,000 lb. will be removed and cast into bars or ingots.

At the Guggenheim Smelting Co.'s plant at Perth Amboy, N. J., two of these machines have been installed, one casting thin anodes at the average rate of from 40,000 to 45,000 lb. per hour, the weight of the charges running as high as 172,000 lb., and the other casting wirebars, in charges of from 110,000 to 115,000 lb. daily. All of the levers for operating the two movements of the ladle and rotation of the wheel are now set at one point and controlled by one man, instead of two, as was the case when the former description was written. In casting wirebars, ingots and other shapes of fine copper the operator is stationed on the central platform, while in the case of anode work, where not as much care is

required and heat is greater, the levers are brought to one side of the wheel and handled by one man at that point, as illustrated in Fig. 1.

The hydraulic power required to operate the turn table and receiving-pot lift is obtained by tapping the boiler feed main, as only a low pressure is necessary. The bosh conveyor is run by means of a 1-H.P. motor, which can take current from any convenient source. Regarding the expense of operation, the actual labor required for casting a charge of 45 tons of copper, and delivering same at top of conveyor ready to be loaded on trucks or cars is given as follows: One furnace man in charge, one operator for machine, two assistants or helpers and one boy for painting molds, although in rough work the painting can be done automatically. It will thus be seen that the cost of casting should be very low. The total force required per charge, for charging pigs or cathodes, melting and refining at night, casting and delivering outside of building, will average 10 men. These are paid $18·75, at Baltimore wages, the day and night foremen only, being classed as skilled laborers.

At the Buffalo Smelting Works, where about one-half of the product of the Calumet & Hecla Co. is refined and cast, one machine has been recently put in operation to cast ingots, mainly, and is giving very satisfactory results. Charges of 80,000 to 90,000 lb. of ingots are cast daily, and much more could be handled, but the capacity is limited by the ability of the furnaces to refine the mineral, which makes so much slag, in spite of the very excellent system of furnaces to which the apparatus is attached. As it is, however, the amount cast at one charge is so large in comparison with former hand ladling, that the saving is very noticeable.

The Boston & Montana Consolidated Copper and Silver Mining Co. is putting in three of these machines at its plant at Great Falls, Mont., each of which will cast 150,000 lb. of anodes per charge.

When it is considered how small the charges were a few years ago, when cast by hand ladlers, the labor being of the hardest description, compared with the above figures of the work now being performed, we can readily see that much progress has been made in the casting of refined and anode copper from reverberatory furnaces. From present indications it would seem that the capacity of these machines is only limited by the output of the furnaces, and by building the latter large enough, 200,000 lb. of copper, or more, may be cast per charge daily.

The advantages of mechanical casting are: 1. Rapidity of the operation, enabling the furnace to be emptied quickly and leaving more time for melting and refining the large charges handled. 2. The great capacity and universal adaptability. 3. The simplicity of the construction and operation and the reduction of the cost for coal and supplies per ton, because of the ability to handle such large charges. 4. The laborious and dangerous hand ladling of the past is done away with; the molds being filled at a point removed from the water bosh, any danger from explosions is avoided, and the copper is not handled until it is ready for loading and weighing.

A machine and accessories cost about $1,500 and bosh and conveyor for anodes about $800, based on recent prices in the East. Weight about 40,000 lb. Figs.

2 and 3 give the arrangement of the casting machine relative to the furnace, the first showing the bosh so placed that the anodes will dump after revolving 180 degrees, the long axis of the bosh being perpendicular to the line of the furnace,

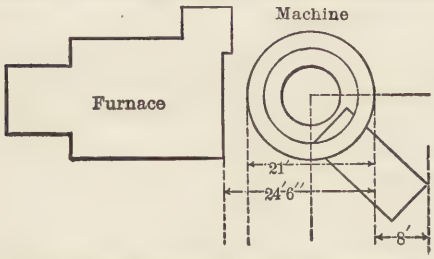


FIG. 2.—Bosh arranged to dump anodes after rotation of 120 degrees.

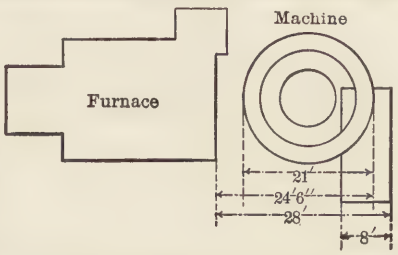


FIG. 3.—Bosh arranged to dump anodes after rotation of 180 degrees.

PLAN SHOWING LOCATION OF CASTING MACHINE.

and the second a design where the anodes are dumped after revolving 120°. Mr. A. L. Walker states that he is selling his casting apparatus on the basis of a fixed royalty of $2,500 for one machine, including full working drawings in detail, which would be a final payment to cover all time.

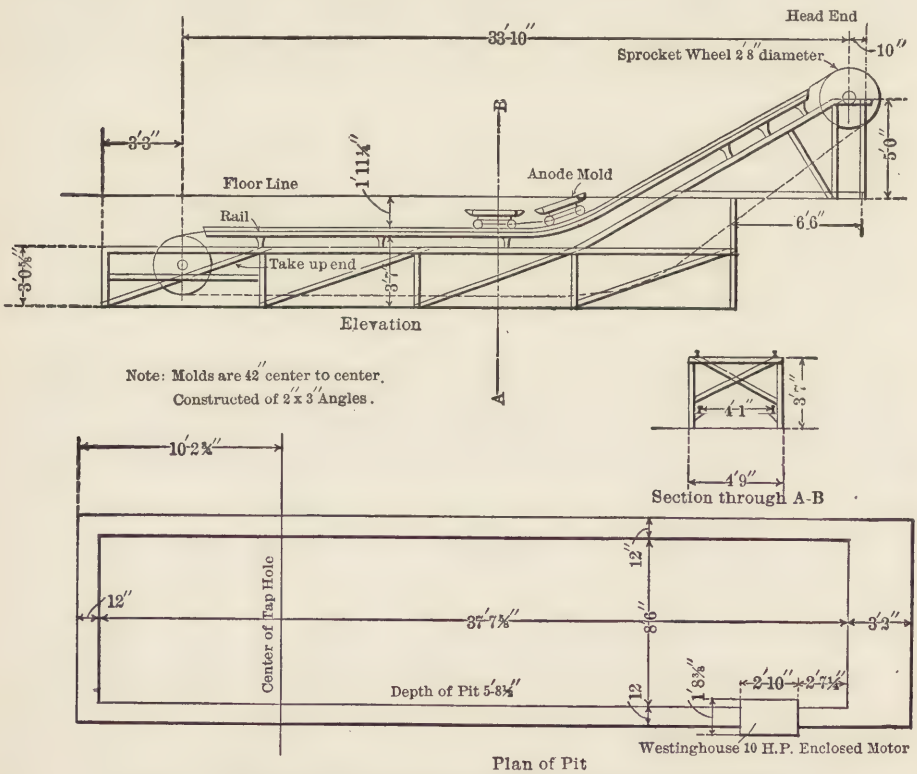


FIG. 4.—DETAILS OF MECHANICAL CASTING APPARATUS.

Another very effective casting and conveying device is the mechanical conveyor supplied by the Link Belt Machinery Co. to the Raritan Copper Works.

A sketch with general dimensions of a machine arranged for casting and conveying anodes is shown in Fig. 4, and a detailed description and photographic view of a similar machine arranged for casting and conveying wirebars are given in the article on the Raritan Copper Works, elsewhere in this section. The anode casting machine has a capacity for delivering over 150,000 lb. of anodes in three hours and costs about $2,800, as against $4,800 (including royalty) for the Walker casting apparatus. With a mechanical conveyor arranged for handling wirebars, charges amounting to 120,000 lb. of bars are readily poured in from four and a half to six hours, depending on the size of bar made, frequently, it is claimed, without a single bad casting.

The use in copper plants of appliances such as the above is rapidly extending and is resulting in a notable decrease in the cost of refining and casting per ton of material treated as compared with the cost of hand ladling.

Electrolytic Refining of Silver and Gold Bullion.—The silver mud or slimes from the copper depositing tanks in several large copper refining works are boiled with sulphuric acid, melted into doré bars, and the latter are parted electrolytically.

The first electrolytic silver refinery in the United States was built in 1886, by the Pennsylvania Lead Co., near Pittsburg, Pa., but was closed down in 1897. It had a daily capacity for parting from 30,000 to 40,000 oz. doré bullion. A similar refinery was built in 1899, or about that time, by the St. Louis Smelting and Refining Co., and this plant has also been shut down. In 1895 the Guggenheim electrolytic silver refinery at Perth Amboy, N. J., was erected and later rebuilt and enlarged, so that it is now probably the most extensive in the world. The Globe Smelting and Refining Co.'s electrolytic silver refinery, near Denver, Colo., was not started until 1898.

Additional data as to the electrolytic silver refineries in operation in the United States in 1900 are given in the accompanying table:

ELECTROLYTIC SILVER REFINERIES OPERATED IN 1900.

No.	Name of Company and Location of Works.	Material Treated.	Estimated Daily Output.	Estimated Daily Capacity of Plant.	No. Tanks.	No. and Capacity of Generators.
1..	Guggenheim Smelting Co., Perth Amboy, N. J.	Doré bullion from lead and copper refinery.	90,000 oz. Troy.	100,000 oz. Troy.	120	One, 62 Kw.
2..	Globe Smelting and Refining Co., Denver, Colo.	Doré bullion from lead refinery and miscellaneous sources.	20,000 oz. Troy.	33,000 oz. Troy.	48	One, 40 Kw.
3..	Balbach Smelting and Refining Co., Newark, N. J.	Doré bullion from lead and copper refinery.	10,000 oz. Troy.	20,000 oz. Troy.	30	One.

The modification of Moebius' refining method, known as the continuous band process, was discontinued at Perth Amboy, chiefly because of the difficulty of removing the deposited silver from the silver belts. According to Mr. Iles,* this difficulty has been overcome, however, by G. Nebel, who discovered that oil

* THE MINERAL INDUSTRY, Vol. VIII., p. 344.

prevents the close adherence of the electrolytically deposited silver crystals to the belt. The band process, as applied at the Globe refinery, has been improved in this and other particulars, among which may be mentioned the substitution of electric contact points of silver for the less conducting and more expensive contact points of platinum.

A fact of much interest to refiners is the erection of an electrolytic plant for refining gold bullion at the new Philadelphia Mint. The process adopted is a modification of the Wohlwill process, in use since 1880 or thereabout at the Norddeutsche Affinerie, at Hamburg. I have given a description of the same in the *Electrical Review,* January 19, 1901.

Thus far over 50,000 oz. gold bullion have been electrolytically refined at the old Mint in Philadelphia, and beside the pure gold, platinum, iridium, silver, etc., in the bullion were recovered as by-products.

In connection with Dr. C. Whitehead, I have designed a plant to be established in the West of a daily capacity for refining at least 7,000 oz. of gold bullion from 750 thousandths fine and upward. In this plant the plates are placed in series circuit, similar to the arrangement in the Hayden copper refining process, and automatic appliances for circulating and regulating the electrolyte are to be used in connection with an improved form of tank.

The power and the floor space required are small and the cost of securing fine gold by this process will no doubt be considerably less than the Government charge for refining the same class of bullion.

Notes on the Leaching of Copper Sulphide Ores.

By S. R. Adcock.

The Action of Ferric Sulphate on Cupriferous Pyrites.—On passing a solution of ferric sulphate or "brown liquor" through a bed of cupriferous pyrites, the iron is readily reduced to the ferrous state, and the copper content of the liquor is increased in proportion to the quantity of iron that has been reduced from the ferric to the ferrous condition.

This action of ferric sulphate on pyrites is invaluable in the wet extraction plant, as a means for extracting copper from low-grade ore, but every care should be taken to insure its absence as far as possible from the liquor before it is allowed to run into the precipitation tanks. If present then it would increase the consumption of iron therein to no purpose, and indirectly prolong the process of precipitation. A newly formed bed of crushed pyrites has at first a rapid reducing action on ferric sulphate, and the richer the mineral is in copper, the quicker and more perfect is the reduction, but as the copper content of the mineral under treatment decreases, its reducing action gets slower and slower until it is noticed that little or no change takes place in the liquor during its passage through the mineral. At this stage, if the liquor is allowed to remain in contact with the mineral until reduction has taken place, it will be found from the analysis of the liquor that (1) the free acid content is on the increase, and (2) the copper content of the liquor does not now increase in proportion to the quantity of ferric iron reduced as was previously the case—

and on continuing this treatment until the reduced liquor shows no further increase in its copper, a rapid increase in the free acid content of the liquor is noted, due to the action of ferric sulphate on the iron pyrites (FeS_2). At a slightly elevated temperature the reducing action of the mineral is more rapid; the above last mentioned reaction is most conspicuous when "terreros" or heaps of crude mineral which, owing to oxidation, heat up to a considerable degree, are washed at intervals.

For a period of some months I carried out at Rio Tinto a series of experiments to determine the amount of copper that could be readily extracted from cupriferous pyrites by washing the mineral with a solution of ferric sulphate, and also to note the chemical changes that take place during the operation. To this end varying quantities of crude smalls, all of which would pass through a 0·25-in. sieve, were washed in small lead tanks with a cold solution of ferric sulphate (2% Fe); the liquor was allowed to remain in contact with the mineral until its color indicated that the greater part of the iron had been reduced, when it was drawn off and a fresh quantity of the ferric sulphate solution added.

These experiments show how rapidly ferric sulphate solutions act upon the cupreous sulphide in the pyrites, and in places where these liquors are plentiful or can be cheaply manufactured they no doubt could be used to advantage for extracting say one-half of the total copper content of mineral running from 1·5% Cu and upward, before it is formed into heaps for treatment by the open air or weathering process. The extraction by this process compares favorably with the (1) open-air calcination, until recently so extensively used at Rio Tinto and the (2) "weathering" or air oxidation processes.

The amounts of copper extracted at different periods were calculated from the analyses of the liquors, and the results obtained from these experiments are given in the subjoined table:

Weight of Mineral Treated.	Copper Content.	Days under Treatment.	Copper Extracted.	Weight of Mineral Treated.	Copper Content.	Days under Treatment.	Copper Extracted.
5 kg.	4·62%	3	31·90%	5 kg.	1·62%	66	50·50%
		8	44·00%			94	60·00%
		23	61·00%	2 kg.	6·49%	30	50·70%
		31	66·00%			61	63·30%
5 kg.	1·62%	4	23·00%			180	79.00%
		13	38·00%				

The open-air calcination as applied to 2·5% Cu mineral yields three-fifths of the total copper (60%) which is at once dissolved out after calcination.* The weathering method yields 88% of the total copper content of the mineral treated in six years.† While carrying out the above trials it was noticed in each case that, after the first two or three washings, the liquors gradually increased in their free acid content, and further experiments were performed to determine the chemical action that was taking place. To determine the action of ferric sulphate on cupreous sulphide, 20 g. of pure copper glance (Cu_2S) crushed to a fine powder, was treated with an excess of the ferric solution. On filtering off the liquor, well washing the insoluble residue,

* J. H. Collins, *Transactions of the Institute of Mining and Metallurgy*, Vol. II., 1893–94.
† J. H. Brown, *Journal of the Society of Chemical Industry*, Vol. XIII., No. 5, May, 1894.

etc., it was found on analysis that 15·39 g. of copper had been dissolved, 27·43 g. iron had been reduced from the ferric to the ferrous condition, and 3·83 g. of free sulphur had been produced. Based on these results it will be seen that the following equation represents the reaction that has taken place:

$$Cu_2S+2Fe_2(SO_4)_3=2CuSO_4+4FeSO_4+S;$$

but having noticed on every occasion when carrying out experiments on the above lines, that the first 50% of the copper is the more easily extracted, I am inclined to think that the reaction is more correctly shown as taking place in two stages, thus:

$$(1)\quad Cu_2S+Fe_2(SO_4)_3=CuS+CuSO_4+2FeSO_4.$$
$$(2)\quad CuS+Fe_2(SO_4)_3=CuSO_4+2FeSO_4+S.$$

With a view to determine the action of ferric sulphate on iron pyrites (FeS_2) 100 g. low-grade ore which had been previously ground to a fine powder, sampled and analyzed, was washed with a strong solution of ferric sulphate (2% Fe) until the analysis of the liquor drawn off from time to time showed that practically all the copper had been removed. The washed mineral was then treated for 63 days with the ferric solution, and at the end of this period it was noticed that the reduction of the ferric iron was taking place almost as rapidly as at the commencement of the experiment. From the analyses of the washings, which were drawn off when the color indicated that reduction had taken place, it was noted that each successive wash showed a slight increase in its free acid content until the copper contained by the mineral had been practically exhausted; at this stage the free acid appeared to have reached its maximum, and from thence was always found present in quantity, directly in proportion to the amount of ferric sulphate that had been reduced by the mineral.

The mineral at the conclusion of the experiment was well washed with distilled water, and dried at 100°C. The following are the analyses of the mineral before and after treatment:

Components.	Before.	After.	Components.	Before.	After.
Copper	0·64%	0·07%	Lead	0·97%	1·10%
Sulphur	51·20%	53·09%	Zinc	2·00%	0·12%
Iron	43·82%	44·60%	Silica	0·39%	0·46%
Arsenic	0·56%	0·21%			
Antimony	0·03%	0·02%	Total	99·613%	99·672%
Bismuth	0·003%	0·002%	Free sulphur	*Nil.*	2·51%

The above analyses show that the copper and zinc originally contained by the pyrites are almost totally extracted by ferric sulphate, the arsenic to a lesser extent in the same time, while all the lead remains in the washed mineral, probably as an insoluble sulphate. It is well also to note that the free sulphur is present in the mineral after treatment.

The results of the analyses of the liquors obtained by washing the mineral for 63 days, after the copper had been extracted, were as follows. During this trial the liquors were kept at a slightly elevated temperature: 45·2 g. of ferric iron reduced to the ferrous state; 44 g. free sulphuric acid formed and 4·2 g. of iron (from the pyrites) dissolved. Based on these results I venture to give the

following equation as that representing the action of ferric sulphate on iron pyrites:

$$11Fe_2(SO_4)_3+2FeS_2+12H_2O=24FeSO_4+12H_2SO_4+S.$$

The amount of pyrites required to effect the reduction is very small, but the reaction in the cold is slow in taking place, unless a large excess of mineral is exposed in proportion to the quantity of ferric sulphate to be reduced; at a temperature of from 50 to 60°C. the reaction takes place much quicker than at the ordinary temperature.

The Chemistry of the Cementation Process for Copper.—A very accurate idea of the amount of iron that will be consumed by a liquor during the precipitation of its copper can be obtained by determining the copper, ferric iron and free acid content, as in an ordinary cementation liquor these bodies are practically the only constituents that attack the pig iron during the precipitation process.

The following equations explain the principal chemical changes that take place in the tanks:

$$(1)\ CuSO_4+Fe=Cu+FeSO_4,$$
$$(2)\ Fe_2(SO_4)_3+Fe=3FeSO_4,$$
$$(3)\ H_2SO_4+Fe=FeSO_4+H_2.$$

Theoretically 56 parts of iron are required to precipitate 63 parts of copper, or 0·888 Fe to 1 Cu. This figure is never obtained in the works as an average consumption, though while at Rio Tinto I frequently tested samples of liquor taken from the middle series of tanks on the precipitation plant, at which stage the liquor usually contains all its iron in the ferrous state, and found that the production of copper was taking place at an expense of iron to copper produced, very nearly approaching the minimum figure.

In general, with ordinary cementation liquors that have been prepared from cupriferous pyrites, the amount of iron consumed in excess depends entirely upon the quantity of ferric iron and free acid, principally the former, there is present in the liquor. From the analyses of a number of samples of the liquor entering and leaving each tank throughout a series constituting a plant for precipitating daily from 10 to 12 tons of copper, it was found that all the ferric iron in the liquor was reduced to the ferrous state during the early stages of precipitation, consequently the copper produced in the first few tanks of the plant, is at the expense of an excessive consumption of iron, when ferric sulphate is present in the liquor. When all the ferric iron has been reduced to the ferrous state—the time required to bring about the reduction depends upon the quantity of iron there is present in the solution in the ferric state, the surface of iron exposed for the liquor to act upon, the temperature of the liquor, etc.—the precipitation of the copper takes place more rapidly and with a minimum consumption of iron. In the last tanks of the series, where the liquor is now weak in copper and consequently precipitation is going on slowly, the free acid is responsible for the high consumption of iron, as compared with the copper produced; by increasing the velocity of the liquor at this point the consumption of iron caused by the free acid can be considerably diminished.

All the ferric sulphate in the liquor is not reduced directly at the expense of

the pig iron as shown by the above equation; some is reduced by its action on the precipitated copper in the tanks thus:

$$Fe_2(SO_4)_3+Cu=CuSO_4+2FeSO_4,$$

but as the copper so dissolved has to be reprecipitated at the expense of metallic iron, the ultimate amount of iron consumed in reducing the ferric iron in the liquor is the same, whether it is iron or copper that has been used up in the first instance in bringing about the reduction.

It is important to watch the iron consumption very closely so that when it is found to be on the increase in proportion to the copper produced, necessary means can be taken to rectify matters, such as by partially or entirely stopping a supply of liquor for a time from a certain heap which is found to be yielding liquors high in free acid or ferric iron, and taking more from other sources where the liquor is in a more suitable condition for precipitation.

An accurate figure can be arrived at each day if desired, for iron consumed per ton of copper produced, from the results obtained by carefully testing the average daily samples of "entrada" and "salida" liquor to determine the amount of copper precipitated, of ferric iron reduced, and of free acid neutralized, and calculating the quantity of metallic iron that would be required to bring about these changes in accordance with the above equations.

To make this point clear I give the following partial analyses—all that is necessary for the calculation—of samples taken on one occasion of liquor entering, and leaving one of the cementation plants at Rio Tinto:

ANALYSES OF LIQUOR ENTERING AND LEAVING TANKS IN GRAMS PER CUBIC METER.

	Entering.	Leaving.
Copper.....	2,064	3
Ferric iron....	1,328	*Nil.*
Sulphuric acid.	1,198	712

CALCULATION IN GRAMS PER CUBIC METER OF LIQUOR.

Cu precipitated: 2,064—3=2,061×$\frac{8}{9}$=1,832 g. of iron required.
Ferric acid reduced: 1,328×$\frac{1}{2}$= 664 g. of iron required.
Sulphuric acid neutralized: 1,198—712=486×$\frac{4}{7}$= 278 g. of iron required.

Total iron required..... 2,774 g.

Two thousand and sixty-one grams of copper precipitated from a liquor of the above class would require 2,774 g. of iron, or 1 part of Cu to 1·345 parts of Fe. Taking the metallic content of the pig iron used at 92% the consumption in this instance works out at 1 Cu to 1·462 pig iron.

The consumption calculated on the above lines, while giving an accurate working figure, does not give the actual consumption. To arrive at the latter it is necessary to add the amount of iron required to precipitate the small percentage of impurities found in the copper produced, and the amount of iron that is removed from the tanks when cleaning up, mechanically mixed with the cement copper; but the iron consumption due to these causes is so slight that for the purpose for which the method was introduced, it was not considered necessary to take them into account.

It will be seen at once from the above figures that on increasing the copper

contents of the liquor, the other constituents cited remaining the same, the relative figure for iron consumed for copper produced, decreases, thus—if for instance the copper precipitated had been 3,000 instead of 2,061 g. per cu. m. of liquor, the consumption would have been $3{,}000\times\frac{8}{9}=2{,}666+664+278=3{,}608$, and $3{,}608\div3{,}000=1{\cdot}203$ instead of 1·345 Fe.

It is a decided advantage to have the liquor for precipitation slightly acid; there usually is sufficient acid formed during the weathering or oxidation of the mineral for this purpose. A slight acidity tends to accelerate precipitation, and to prevent as well the falling out of basic iron salts while precipitation is taking place. In general, the acid content of a cementation liquor for precipitation in a running stream, should not be more than from 0·1 to 0·2%. When above this figure its action on the pig iron is more conspicuous and the iron consumed as compared with the copper produced increases accordingly.

Respecting ferric iron, every precaution should be taken to insure as far as possible that all the iron in the liquor be in the ferrous state before it is allowed to enter the precipitation tanks; for in almost every instance the cause of excessive consumption of iron during precipitation, can be traced to the high ferric iron content of the liquor under treatment.

When arsenic is present in the pyrites employed for the preparation of the cementation liquor, it passes into solution along with the soluble salts produced, and is to an extent precipitated with the copper. When the liquor is rich in copper and precipitation is taking place rapidly, the amount of arsenic precipitated is comparatively very small—but as the liquor gets weaker in copper, and consequently is precipitating slowly, the proportion of arsenic to copper precipitated is much higher. Bearing on this point, I would mention it was noticed at Rio Tinto in one particular instance that during the precipitation of the first portion (82%) of the total copper content of a liquor, the ratio of arsenic to copper precipitated, stood at 1 to 119 of copper, while during the precipitation of the remainder of the copper (12%) it stood at 1 to 8·4 of copper.

As is well known, arsenic is a most undesirable impurity for copper to contain, yet under ordinary conditions is always present in cement copper produced from liquors containing it—a number of methods have been suggested for the removal of arsenic from the liquor before precipitating the copper, but up to the present time the enormous bulk of liquor to be treated has been the obstacle.

The liquor leaving the cementation plant, after precipitation, consists principally of a solution of ferrous sulphate, carrying a fair percentage of zinc sulphate, when the mineral under treatment contains blende. At Rio Tinto a portion of this liquor is utilized for washing the weathered mineral, for which purpose it has a decided advantage over fresh water, as there is a considerable amount of ferric sulphate formed in the liquor as it percolates through the ventilated heaps, which readily attacks and dissolves the copper sulphide in the mineral, in addition to washing out the soluble salts. The wash liquor leaving the mine gradually oxidizes as it passes down the river, changing in color from a deep green to chocolate. A portion of the iron is deposited in the bed of the river as a basic sulphate, but the greater part of it passes in solution to the sea.

The Elimination of Impurities from Copper Mattes.

By Edward Keller.

Now that most of our great Western smelting works are no longer compelled to dispose of their copper mattes in the Eastern and European markets, but have introduced methods for their immediate conversion to metallic copper, this product no longer possesses the same commercial importance as before. Its properties and characteristics, metallurgically, however, still offer an interesting study, which cannot fail to have an important practical bearing; and for that reason I venture to offer the following notes of past experience.

Composition and Character of Mattes.—In the United States the term of matte is applied to any sulphide-product obtained by smelting sulphide ores. What in England and Wales is subdivided into coarse metal, blue metal, and white metal, is in this country generally described under the class-name of copper-matte. The elements essential for the formation of the latter are self-evidently copper and sulphur; the former being subject to substitution by other metals, especially iron, which is in reality a regular constituent of all mattes. In a few exceptional instances lead and nickel must also be classed as essential constituents. All other elements may generally be considered as being merely admixed impurities.

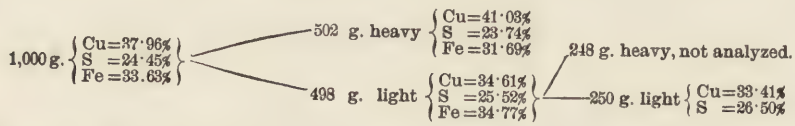
The true chemical character of copper mattes does not yet seem to have been definitely determined; *i.e.,* it is still more or less of an open question whether they are true chemical compounds, or mixtures, such as igneous rocks. The following arguments may be offered in favor of the latter, as against the former assumption: Stable chemical compounds when changing from the liquid to the solid state remain uniform throughout the whole body of the compound. There can be no liquation as it is generally termed, for the reason that the molecules are at equilibrium. The same may be said of isomorphous mixtures, and of eutectic solutions. That mattes, or at least some mattes, do not conform to this requirement may be observed from the following test: A large matte pot was filled with molten matte and left to solidify; then samples were taken from the top, center, and bottom of the cone. Repeated analysis of several of the elements gave the following results as to their distribution:

ANALYSIS SHOWING LIQUATION IN CONE OF COPPER MATTE.

Sample.	Copper.	Lead.	Silver.	Gold.
	%	%	Oz. per ton.	Oz. per ton.
Top	60·07	1·664	43·9	1·72
Center	60·29	1·716	44·7	1·75
Bottom.....	60·77	1·785	44·0	1·72

From the above it is quite evident that of the elements determined, copper and lead have concentrated perceptibly toward the bottom, while silver and gold have tended toward the center of the cone. A more direct method to test whether a matte is a compound sulphide or a mixture of individual sulphides

was attempted by applying hydraulic separation. A clean piece of matte was selected containing practically no magnetic oxide and of the following composition: Cu, 37·96%; S, 24·45%; Fe, 33·63%; Zn, 1·25%; Pb, 1·02%; Sb, 0·26%; As, 0·065%; insoluble, 1·15%; Ag, 26·7 oz. per ton; Au, 0·04 oz. per ton. For such a test, it is essential to select a chemically uniform piece, otherwise a separation of a higher from a lower grade matte, merely, might be obtained. The sample was all passed through a 100-mesh sieve. The separation was attempted by the primitive way of washing in a pan, and the practical end was soon reached. Starting with 1,000 g., the separation proceeded as follows:



Although the separation does not appear as a marked success, being confined to very narrow limits, yet the results are positive, indicating individual and segregated sulphides; otherwise there could be no increase or decrease of the quantity of the several elements in the separated portions. That the insoluble portion of the original matte (a little slag) was not a disturbing factor is indicated by the increasing tenor of sulphur in the light portions. Although this matte, when in coarse particles, was not attracted by the magnet, yet when finely ground and under water, a separation of a small portion by magnetic means was possible. This portion was composed as follows: Cu, 31·64%; S, 17·22%; Fe, 46·57%; Pb, 1·04%; Sb, 1·25%; As, 0·29%; Ag, 0·12 oz. per ton.

It could not be expected to separate out by such crude means a distinct, individual substance; yet any substance separated and differing in composition from that of the matte itself, is proof of the heterogeneous character of the latter. The fact of the existence of individual sulphides established, and their extremely intimate intermixture, by the difficulty of their separation, demonstrated, it follows that the several sulphides in the molten state are mutually soluble in all proportions up to their freezing point, at which they segregate in minute crystals or amorphous particles.

The nature of the individual sulphides, also, is a matter of controversy. If a matte of the composition, Cu, 43·13%; S, 23·10%; Fe, 26·18%; Fe_3O_4, 0·61%; Zn, 2·07%; Pb, 1·426%; Bi, 0·007%; Sb, 0·267%; As, 0·0437%; Te, Se, 0·005%; insoluble, 2·97%; Ag, 24·5 oz. per ton, be calculated as to its main sulphides, according to the two different opinions entertained of their character, it is found to be of the following composition:

RATIONAL ANALYSIS OF COPPER MATTE.

	Cu_2S.	FeS.	Fe_2S.	Fe.	ZnS.	PbS.	Sb_2S_3.
	%	%	%	%	%	%	%
I.....	54·01	19·17	17·59		3·09	1·65	0·37
II.....	54·01	29·92		6·84	3·09	1·65	0·37

Those who write the iron sulphides in the first manner take it for granted

that an iron subsulphide exists. Those who adopt the second way deny the existence of the subsulphide, and assume that metallic iron is dissolved in the iron monosulphide. In behalf of the former interpretation it may be said, that the amount of iron is not an indefinite or accidental one, because, as will be shown by the analysis of various mattes, the sulphur present in nearly all mattes is of an almost constant tenor, ranging between 22 and 24%. The sulphur, therefore, appears as a nucleus of constant quantity in the mattes, around which the metals are grouped in equilibrium, and consequently also in definite quantity, which would not seem probable if any of them were merely dissolved. This applies to the mattes at the temperature of their formation. The composition of the magnetic portion of such mattes, as given above, and the formation of ferruginous bottoms, composed as the subjoined analyses show, speak for the presence of metallic iron.

ANALYSIS OF FERRUGINOUS BOTTOMS IN BLAST FURNACE.

	Cu.	S.	Fe.	Pb.	Sb.	As.	Ag.
	%	%		%	%	%	Oz. per ton.
I.....	14·63	4·38	77·04	0·46	0·48	0·54	10·0
II.....	10·02	3·68	79·10	0·35	0·61	0·57	

The existence of an iron subsulphide, or of a monosulphide holding metallic iron in solution, is a question connected only with the lower grades of matte. In mattes of over 55% Cu the composition indicates the presence of copper subsulphide and of iron monosulphide alone.

Sampling of Matte.—In connection with the question of homogeneity or heterogeneity of matte, a few remarks on the subject of sampling may be appropriate. Among smelting men it is generally taken for granted that a piece of matte taken from any part of a bed of matte is a fair sample of the whole bed. That this is not strictly true has been shown above by the demonstration of the fact of liquation, or the uneven distribution of some of the elements in a cone of matte. In sampling large quantities of this material, the same laws must be applied as those which govern in ore-sampling, *i.e.*, aliquot parts of all the various sized particles constituting the whole must be obtained for the sample. Some years ago I had occasion to show the inadequacy of a certain sampling-machine. The matte was crushed so fine that every particle would pass through a 0·2-in. mesh screen. The matte was of great constancy as to its copper content. During several days the bulk and the sample of this crushed matte were tested as to their composition of coarse and fine particles, for which purpose a 16-mesh screen served as a separator, the portion going over this screen being the coarse, that passing through the screen being the fine portion of the matte. The bulk was found to contain 64% coarse and 36% fine particles, while the sample was composed of 52·5% of the former and 47·5% of the latter constituent. An analysis of the coarse and the fine portions, showing the copper and precious metal contents, is given in the table at the top of the following page.

It was therewith plainly proven that the sample, at least with regard to copper, could not be a strictly correct one. The apparatus giving this result did not take a portion of the stream of matte, running through it, all the time, nor the

whole stream at intervals. A machine installed on the latter principle yielded correct samples.

	Copper.	Silver.	Gold.
	%	Oz. per ton.	Oz. per ton.
Coarse portion..	59·64	59·55	0·29
Fine portion.....	60·21	60·40	0·28

Impurities in Mattes.—In the accompanying table are given analyses—some partial, some more or less complete—of mattes from most of the chief copper districts of North America. Surveying the various components constituting these mattes, one of them at once appears as of a strikingly foreign character. It has, in fact, been strongly doubted that magnetic iron oxide could be a component part of a copper matte; but its presence has been convincingly demonstrated by separation and analysis. Its presence, nevertheless, may be designated an accidental one, being due to some conditions in smelting, the exact character of

ANALYSES OF COPPER MATTES FROM SOME OF THE CHIEF COPPER DISTRICTS OF NORTH AMERICA.

Source.	Cu.	S.	Fe.	Fe_3O_4.	Ni.	Co.	Zn.	Pb.
	%	%	%	%	%	%	%	%
Anaconda, Reverb. F	60·76	23·25	11·43	1·13	0·0076	0·0034	2·41	0·5900
B. & M. Co., Reverb. F	49·34		22·44					0·0738
B. & M. Co., Blast F	61·42		14·50					0·0370
Parrot, Reverb. F	29·41	23·70	25·35	12·60				
Parrot, Blast F	36·15	23·88	24·97	8·51				
Copper Queen, Blast F	54·89	23·36	20·25		0·0341	0·0240	0·34	0·1178
Jerome, Ariz	55·00	23·96	13·85	2·58			1·24	3·0250
Mountain Copper Co., Cal	57·83	22·47	15·28		0·0050		2·09	0·0719
Ducktown, Tenn. (*a*)	49·17	19·45	22·79		0·0436	0·0222	0·77	0·1294
Silver City, N. M. (*b*)	53·73	23·17	19·49		0·0354	0·0498	0·26	0·0022
Elizabeth M. Co., Vt	21·36	22·95	41·03	10·44	0·0020	0·1984	0·24	0·0226
Le Roi Mine, B. C	49·02	22·78	23·86		0·0383	0·0332	0·09	0·0920
Canadian Copper Co., Ont	24·54	23·24	28·65	7·32	15·5600	0·5520		0·0272
Leady Matte (Mexico)	36·23	19·54	17·48		0·2530	0·0474	1·84	18·54
Santa Rosalia, Mexico (Matte)	61·52	22·52	13·68		0·0645	0·4140	0·2333	0·0270
Santa Rosalia, Mexico (*d*) (Black Copper)	91·45	1·00	3·52		0·1576	0·6200	0·7182	0·1322

Source.	Bi.	Sb.	As.	Te.	Se.	Ag.	Au.
	%	%	%	%	%	Oz. per ton.	Oz. per ton.
Anaconda, Reverb. F	0·0420	0·0790	0·0450	0·0112	0·0038	60·4	0·30
B. & M. Co., Reverb. F	0·0337	0·1010	0·0480	0·0021		14·6	0·05
B. & M. Co., Blast F	0·0049	0·1330	0·1280	0·0042		18·2	0·05
Parrot, Reverb. F							
Parrot, Blast F							
Copper Queen, Blast F	0·0044	0·0232	0·0171	0·0088	0·0113	6·0	0·10
Jerome, Ariz	0·0174	0·2693	0·0914	0·0474	0·1172	127·0	2·28
Mountain Copper Co., Cal	0·0014	0·0143	0·0130	0·0060		13·4	0·51
Ducktown. Tenn. (*a*)	0·0	0·0206	0·0	0·0	0·0	5·9	0·04
Silver City, N. M. (*b*)	0·0	0·0032	0·0	Trace.		1·2	Trace.
Elizabeth M. Co., Vt	0·0	0·0	0·0041	0·0	0·0082	2·4	0·0
Le Roi Mine, B. C	0·0008	0·0348	0·0434	0·0063	0·0	26·0	10·72
Canadian Copper Co., Ont	0·0008	0·0068	0·0042	0·0	0·0	5·3	0·05
Leady Matte (Mexico)	0·0	1·1330	0·7690	0·0340		112·4	0·68
Santa Rosalia, Mexico (Matte)	0·0008	0·0032	0·0013	0·0	0·0	2·2	Trace.
Santa Rosalia, Mexico (*d*) (Black Copper)	0·0030	0·0128	0·0197	0·0	0·0	6·0	Trace.

NOTE.—Where blanks are left under the head of the elements these have not been looked for or determined. When the elements were not found it is so indicated by 0·0. (*a*) This matte is partially oxidized—whether originally in the furnace or afterward is unknown. (*b*) This matte is not from one of the large producers. It is inserted as an example of exceptionally pure matte. (*c*) This copper-nickel matte also contains a small amount of platinum, which I found to be 0·30 oz. per ton. (*d*) The ores of the Boleo Co. are oxysulphides. The furnaces produce both matte and black copper from the same charge. For that reason the analyses of both products are here given. In these products the following additional elements were determined: In matte, Mn, 0·938%; P, 0·019%. In copper, Mn, 0·0%; P, 0·18%.

which has not yet been established. It may also originate in the calcined portion of an ore-charge, the smelting failing to reduce it to slaggable form. Its formation in the blast furnace has been attributed to high-pressure blast.* Against this explanation may be pointed out the fact, that in smelting matte to regulus in a reverberatory furnace under ordinary atmospheric pressure, magnetic oxide is formed in profusion, while under the high-pressure blast of a converter it remains entirely absent. The slags in the former process are highly magnetic, while in the latter they show no magnetism at all, ordinarily speaking. The presence of greater quantities of magnetic oxide in the lower grade mattes than in the higher ones, is most probably attributable to difference in copper-content and specific gravity, these being, in a few instances, corelated as follows:

	I.	II.	III.	IV.
Copper, %.....	13·62	43·00	60·22	80·00
Specific gravity.	4·80	5·18	5·42	5·55

The specific gravity of magnetic oxide is from 5·0 to 5·2, and it follows, therefore, that it will sink from the slags into the lower grade mattes, while when the higher grade mattes are formed it will remain associated with the slags. On these principles it is finally eliminated from all mattes by going into the slags, and it has no influence whatever on the properties of the metallic copper produced from them. It is, however, a harmful element in the process of smelting; doing damage, according to Dr. Peters, in at least five different ways: (1) It robs the slag of the iron needed for flux. (2) It lessens the dissolving power of the matte for silver and perhaps for gold. (3) It increases the quantity of matte to be treated later. (4) It makes the matte exceedingly tough and tenacious, and expensive to break or pulverize. (5) It makes the charge less fusible. To these may be added:

When retained in the slags it renders the latter sticky, and they consequently become greatly enriched in copper and precious metals.

Besides the constituents of the mattes that have been determined and are shown in the table of analyses, there may, of course, be present a number of others. Among these is to be mentioned manganese, which I have determined in the Boleo matte alone, and which probably occurs to some very small extent in most of the mattes. It is one of the elements, like zinc, cobalt, etc., rarely met with in metallic copper produced by the converter process. Mr. Mager, chemist of the Baltimore Copper Smelting and Refining Co., has repeatedly called my attention to its presence in United Verdi converter copper of Arizona. It makes its presence evident in nitric or sulphuric acid solution by the purple color of permanganic acid when subjected to electrolysis.

Tin has been found associated with some copper ores in Cornwall, but I am not aware of its presence in any of the American mattes. If it were present, the mode of analysis would have included its quantity in that of the antimony. It is also unknown whether platinum occurs in any other matte than that from Sudbury. Phosphorus has been reported as being present in some metallic cop-

* Peters, *Modern Copper Smelting*. 1895.

per. I have never tested any but the Boleo matte for it; its presence therein being shown by the reports of the company.

All the elements mentioned above, and shown in the table as composing the various mattes, with the exception of magnetic iron oxide, follow the copper to its metallic state in varying degrees, according to the process of reduction, as shall be shown hereafter.

Elimination of Impurities in the Reverberatory Process.—Some years ago I had the very favorable opportunity of determining the elimination of the impurities contained in the Anaconda matte, as treated by the reverberatory process in Baltimore, Md. The sampling extended over a working period of eight months and covered many million pounds of material. The results from the complete process—from the calcination of the matte to the refining of the blister copper—are embodied in the following data:

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%	%	%	%
Impurities in matte.....	60·76	0·5900	0·0420	0·0790	0·0450	0·0150
Impurities in copper.....		0·0093	0·0032	0·0651	0·0586	0·0098
Elimination of impurities.		99	54	50	21	60

In these determinations should have been included the element nickel, as being only eliminated partially, while such elements as sulphur, zinc, manganese, iron and cobalt were neglected because they often are not found in the metallic copper at all, or occur only in such very minute quantities that it is safe to say that they are always eliminated to the extent of over 99% in this process. Silver and gold are, of course, not eliminated in the same sense as the other elements. Their loss is mainly due to the loss of metallic copper, which they follow.

The operations of the reverberatory process as conducted at Baltimore were the following: (1) Calcination; (2) matte smelting, or production of regulus (regol); (3) production of blister copper; (4) refining. There was no selecting, *i.e.*, there was only one grade of copper produced. It was impossible to determine quantitatively the elimination of the impurities in each of the individual operations. The approximate results arrived at will be explained in the following paragraphs.

Calcination.—The data as subjoined served as the basis for the calculations of elimination in this operation.

ANALYSIS OF RAW AND OF CALCINED MATTE.

Material.	Cu.	S.	SO_4.	Fe.	Fe_3O_4.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.	Ag.	Au.
	%	%	%	%	%	%	%	%	%	%	%	Oz. p. ton.	Oz. p. ton.
Raw matte.....	60·89	23·22		12·28	0·34	1·70	0·568	0·0501	0·101	0·0481	0·0101	61·1	0·20
Calcined matte.....	61·45	16·45	0·99	10·45	3·03	1·66	0·540	0·0450	0·0967	0·037	0·0082	62·2	0·20

PARTIAL ANALYSIS OF CALCINER FLUE-DUST.

	Cu.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%	%	%	%	%
Flue-dust..	18·74	1·40	0·345	0·0205	0·202	0·382	0·014

ELIMINATION OF ARSENIC AND ANTIMONY IN DEAD-ROASTING.

	Raw Matte.	Calcined Matte.	Elimination.
	%	%	%
Antimony.....	0·079	0·075	5·0
Arsenic.....	0·045	0·038	15·5

RELATIVE AMOUNTS OF ELEMENTS GONE INTO CALCINER FLUE-DUST.

	Cu.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%		%	%	%
Flue-dust..	1·00	1·86	1·88	1·60	8·15	27·16	2·80

The errors of sampling and analysis in the raw and in the calcined matte were deemed as being in all probability too great to permit the calculation of the actual elimination of the impurities in calcination, or roasting. The other data were, therefore, taken to find a more satisfactory solution of this question. The result is given below:

APPROXIMATE AMOUNT OF ELEMENTS IN MATTE GONE INTO CALCINER FLUE-DUST.

	Cu.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.
Per cent...	0·18	0·34	0·34	0·29	1·47	5	0·50

The amount of the same elements that may have passed through the flues and stacks into the atmosphere was, of course, not ascertainable; but it would undoubtedly be a very small factor.

Matte Smelting.—By smelting the product of the preceding operation, *i.e.*, the calcined matte, in a reverberatory furnace, the following materials were the resultants: Regulus or regol, copper bottoms, slag, and flue-dust, of which the composition was determined as follows:

	Cu.	S.	Fe.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.	Ag.	Au.
	%	%	%	%	%	%	%	%	%	Oz. per ton.	Oz. per ton.
Regulus.....	81·38	15·90	0·75	0·031	0·216	0·0244	0·0633	0·0411	0·0102	78·5	0·11
Copper bottoms...					0·398	0·128	0·265	0·343	0·0022	173·5	1·18

	SiO_2.	FeO.	Fe_3O_4.	Al_2O_3	CaO.	ZnO.	Cu.	Pb.	Bi.	Sb.	As.	S.	Zn.	Te, Se.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
I. Matte smelt'g slag.	29·68	22·99	18·00	9·62	3·75	3·80	10·88	0·80	0·008	0·071	0·014	0·341		
II. Matte smelt. slag.							3·34	0·3639	0·0052	0·0184	0·005			
Flue-dust.....							36·40	0·339	0·062	0.0713	0·0631		0·622	0·0128

By a comparison of the calcined matte with the resulting regulus and copper bottoms, the following additional data were calculated:

ELIMINATION OF IMPURITIES IN REGULUS.

	Fe.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.
Per cent...	94·60	98·59	69·85	59·02	50·6	16·14	6·00

CONCENTRATION OF IMPURITIES IN COPPER BOTTOMS.

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
Per cent...	1	0·45	1·75	1·62	5·70	0·16

These latter figures mean that with every per cent. of copper in the original calcined matte reduced to the metallic state, 0·45% of the original lead, 1·75% of the original bismuth, etc., have gone to form the copper bottoms. The percentage of elimination in regulus for those elements which have concentrated in the copper bottoms, *i.e.*, bismuth, antimony, and arsenic, is, as applied to the full operation of matte-smelting, too high; for the other elements, which have concentrated in the regulus, it is too low. This becomes self-evident when it is considered that regulus and bottoms are again brought together in the succeeding process. It is impossible to give the exact value of elimination in this smelting. The average amount of copper and impurities slagged has been found to be: Cu, 4·18%; Pb, 41·5%; Bi, 5·6%; Sb, 18·2%; As, 9·9%.

Since the slags, on account of their high tenor in copper, must be resmelted, a certain amount of the impurities will also return to the regular circuit of operation.

Production of Blister Copper.—The furnace employed in this operation was of the same kind as in the previous one. While in the matte smelting the chief object is the removal of the iron by slagging, the blister process sets out to convert the regulus to metallic copper, *i.e.*, its chief object is to remove the sulphur by combustion. Quantitative figures for elimination in this operation cannot be given. The copper and impurities in the resulting materials were determined as follows:

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%	%	%	%
Blister copper	99·0	0·0080	0·0509	0·0958	0·0635	0·0149
Blister slag...	20·43	6·1054	0·0049	0·0320	0·0039	0·0025

By calculation there was further found:

RELATIVE SLAGGABILITY OF ELEMENTS IN BLISTER PROCESS.

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
Per cent...	1	1·95	0·80	2·02	0·38	0·98

Refining of Black and Blister Copper.—In an article in THE MINERAL INDUSTRY, Vol. VII., I dwelt at some length on the operation of this process, there also giving numerous analyses of its materials. In the following I feel myself justified, therefore, in confining my remarks to a few supplementary data. I have since had the opportunity of analyzing Chili bars before and after refining, arriving thereby at the following results:

	Fe.	Co.	Ni.	Pb.	Bi.	Sb.	As.	Te, Se.	S.
	%	%	%	%	%	%	%	%	%
Chili bars, black copper.....	1·1378	0·1376	0·1717	0·1105	0·2435	0·0689	0·2055	Trace	0·8100
Chili bars, refined.....	0·0017	0·0044	0·0975	0·0275	0·2285	0·0673	0·2040	Trace	0·0067
Elimination.....	99·85	96·80	43·23	75·11	6·12	2·32	0·53		99·17

In such a direct test as the above, the errors of sampling and analysis undoubtedly form a very serious factor in the smaller figures for elimination, and for that reason those for bismuth, antimony and arsenic are in all probability much below the actual values. This assumption is corroborated when conclusions as to elimination are drawn from the amount of elements slagged in refining. This has been done from the following data:

COPPER AND IMPURITIES IN REFINED COPPER AND IN REFINERY SLAGS.

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%	%	%	%
Refined copper..	99·25	0·0103	0·0040	0·0630	0·0211	0·0072
Refinery slags...	44·47	0·5936	0·0020	0·2044	0·0490	0·0026

Since the composition of the original blister copper was unknown the sum of impurities in refined copper and slag was substituted therefor, and by calculation the following minimum results were arrived at:

PROPORTION OF ORIGINAL COPPER AND IMPURITIES SLAGGED IN REFINING.

	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.
Per cent...	1	52·1	1·07	5·90	5·07	0·84

These are minimum figures for elimination because the amounts volatilized are neglected. The latter would probably be a high factor for bismuth, selenium and tellurium, since these are quite volatile and not highly slaggable.

Secondary Products in the Reverberatory Process.—The slags from the matte smelting, and the blister process, mixed sometimes with flue-dust in order to regain the copper, were smelted in a blast furnace with the addition of iron pyrites, thus producing a secondary matte, which, with its copper and impurities, would go through the whole metallurgical circuit a second time. The slag from

ANALYSIS OF SECONDARY MATTE OF REVERBERATORY PROCESS.

	Cu.	S.	Fe.	Fe_3O_4.	Zn.	Pb.	Bi.	Sb.	As.	Se, Te.	Ag.
	%	%	%	%	%	%	%	%	%	%	Oz. per ton.
Per cent.....	43·13	23·10	26·18	0·61	2·07	1·426	0·0071	0·2677	0·0437	0·005	24·5

COPPER AND IMPURITIES FROM ORIGINAL MATTE CONTAINED IN SECONDARY MATTE.

	Cu.	Pb.	Bi.	Sb.	As.	Se, Te.
Per cent...	5·3	18	1	25	7	2·5

the blast furnace was the waste product. The analytical data with conclusions are given on the preceding page.

COMPOSITION OF BLAST FURNACE SLAG.

	SiO_2.	FeO.	Al_2O_3.	CaO.	ZnO.	Cu.	Pb.	Sb.	As.
Per cent.....	36·55	43·97	6·56	10·05	2·01	0·27	0·26	0·0317	0·0033

The refinery slags were added to the charges of the blister furnaces, and were thus reduced without any extra process.

Conclusions Drawn from the Baltimore Reverberatory Process.—(1) In the process of calcination or roasting, the element eliminated in by far the greatest proportion is the arsenic. The figure which I have given—5%—is a minimum figure, since the amount escaped into the atmosphere by volatilization is neglected. This 5% constitutes one-fourth of the arsenic eliminated in all the operations. Antimony is next with approximately 3% of the total elimination allotted to calcination. The elimination of all the other elements in this operation is a negligible quantity.

(2) In the process of matte smelting, which is an oxidizing roasting at a very high temperature, we have seen by the composition of the regulus produced, that iron and zinc were eliminated to the extent of over 95%. Cobalt and manganese, had they been determined, would undoubtedly have shown an equally high figure. Lead comes next to these elements with a high percentage of elimination. Bismuth, antimony and arsenic evade elimination to a great extent by retreating into the copper bottoms, but there can be no doubt that for all of the above elements the maximum degree of elimination in the reverberatory process takes place in the operation of matte smelting, which conclusion will later be corroborated by further data. How nickel behaves here is not known. Since selenium and tellurium concentrate into the regulus, and as they are also oxidizable and volatile, it follows that they too must be largely eliminated in this smelting.

(3) In the operation of producing blister copper practically the same conditions as to oxidation exist as in the previous process, although the temperature during the greater part of the time is somewhat lower. We have already seen that in this the greatest portion of the sulphur is removed. The formation of metallic copper begins with the start of this operation, and it is, therefore, the most unfavorable for the elimination of those elements which we have seen to concentrate in the metallic bottoms, *i.e.*, bismuth, antimony and arsenic. For selenium and tellurium the maximum elimination is undoubtedly performed here, since they concentrate more and more in the decreasing quantity of regulus, thus offering the most favorable conditions to oxidation. The latter conditions also pertain to such elements as zinc, cobalt, iron, manganese and lead.

(4) In refining we have seen that a large proportion of sulphur, iron, cobalt and lead were removed. The same would unquestionably be the case with zinc and manganese. Nickel is eliminated to a moderate extent, while the other elements showed but small figures.

From the foregoing description of the reverberatory process, as practiced in

Baltimore, it follows that the impurities in the mattes may be classed in two groups. One, which may be called the non-persistent, consists of the elements, sulphur, zinc, iron, cobalt, lead and manganese. These elements remain with the copper only in very small portions, and some of them can often not be found at all in it. The group of persistent elements, being nickel, bismuth, antimony, arsenic, selenium and tellurium, is characterized by the fact that these elements always follow the copper into the metallic state in large proportion. By what has thus been demonstrated it becomes quite evident that in no one of the operations of the reverberatory process, nor even in all of them combined, is any one of the more deleterious elements completely eliminated from the copper. Consequently, as may be seen from the composition of the various mattes, nearly all of the copper directly produced by dry metallurgical processes from the latter, is unfit for most industrial purposes, or is rendered too valuable by its content in precious metals. It is therefore subjected to electrolytic refining, to eliminate the impurities to within infinitesimal quantities, and to recover practically the full contents of the precious metals. But even for the latter process some coppers are too impure to render it perfectly successful. Fortunately all the great copper mines and smelters produce comparatively pure matte, and since the converter has superseded the reverberatory in nearly all instances, the great bulk of the copper now produced is of sufficient purity to be advantageously and successfully treated in the electrolytic refineries. Nature has thus favored economy at the cost of individuality, for at the present time it is only in exceptional instances that the converter is not used, and that older methods are still employed, or that newer and exceptional ones might be introduced. Next to the copper smelting works the lead smelting works are the greatest producers of copper. I have given an analysis of a Mexican leady matte. Similar ones are undoubtedly produced in Pueblo, Denver, Omaha, and other works. Subjoined is given an analysis by Mr. J. Johns of a sample of copper from one of those localities: Cu, 94·04%; Fe, 0·018%; Ni, 0·3866%; Pb, 2·17%; Bi, 0·0056%; Sb, 0·951%; As, 1·223%; Te, Se, 0·175%; S, 0·0965%; Ag, 185·0 oz. per ton; Au, 1·73 oz. per ton.

Such copper cannot, of course, be employed for any industrial purposes, and it is an undesirable article even for any treatment. It is an example by which to point out the value of improved metallurgical methods to produce purer metallic copper.

All methods or processes, patented and unpatented, which have been suggested or introduced for the purpose of eliminating certain impurities from the mattes have been based on the same general principle. It is the principle, that the impurities in question have a greater affinity for the metallic elements than they have for their sulphides. Hence, such metals as copper, lead, iron, nickel and cobalt have been credited at different times, according to the patentees, to possess the property of totally eliminating certain impurities, notably antimony and arsenic, from copper mattes. Most of these statements seem to have been assumptions without any corroborative evidence in the way of analytical figures, and they exaggerate the facts inasmuch as no element, with the possible exception of gold, can be totally eliminated from the mattes by any metal. Furthermore, as

will be shown, some elements are not only not eliminated from, but also can be concentrated in the mattes, just as others can be concentrated in the metals.

The Selecting Process.—When, according to the principles just set forth, in the reverberatory process a portion of the matte or regulus was converted into metallic copper, as so-called bottoms, and the small amount of metal so produced was separated from the remaining larger amount of regulus for the purpose of purification, we had what was long known as the "selecting process." The purer copper from the regulus, known as "best-selected copper," was of great importance before the advent of American lake copper and electrolytic copper. The greatest secret, according to Dr. Percy, in the production of good, best-selected copper was the selection of the purest copper ores to start with, and yet much of it was found to be "extremely bad."

The distributions of the precious metals and impurities that take place in the selecting process, have been more thoroughly studied by Allan Gibb* than by any other authority. The conclusions reached in his research were the following:

Gold.—With a reduction of 8·2% of the total copper as bottoms, they contain 41·5% of the total gold; while when 14·4% of the copper is reduced to bottoms, the whole of the gold is found in them. Traces sometimes remain with the regulus, too small, however, to be weighed.

Silver.—Silver nearly reaches its maximum concentration in bottoms when 19% of the total copper is separated in this form, 42·9% of the total silver being then contained in them.

Tin, Antimony, Arsenic and Bismuth.—Of these four metals, tin is concentrated in the bottoms in the highest degree, antimony approaches tin in this respect, arsenic is concentrated in smaller proportions, and bismuth scarcely at all. With 20·6% of the total copper reduced it contains 93·4% of the total tin. When 8·2% of the total copper was reduced, 21·0% of the total antimony was found with it in the bottoms. This proportion rises to 80·8% of the total antimony when 17·3% of the total copper is separated. From this point the proportion of antimony which concentrates in the bottoms does not increase much with an increase in the amount of copper separated, only reaching 93·7% of the total antimony when 47·5% of the total copper is separated as bottoms, and actually receding to 92·6% Sb with 54·5% Cu. With a separation of 8·2 and 16·0% of the total copper as bottoms, 11·1 and 43·1% respectively of the total bismuth passes into the copper bottoms. There is hardly any further increase in the concentration of the bismuth with any increased proportion of copper reduced. Thus, when 47·5% of the total copper is separated, only 47·6% of the total bismuth is found with it. The proportions of the total arsenic which concentrate in bottoms are 21·5, 30·6 and 60·2%, respectively, when 8·2, 16·0 and 25·2% of the total copper is separated in that form. Arsenic thus differs from bismuth in the rate of its elimination from the main bulk of the copper. With 8·2% of the copper as bottoms, a larger proportion of arsenic than of bismuth passes into them; while with 16·0% the proportion of bismuth concentrated into them is greater than that of arsenic. But at the latter point the concentration of the bismuth has practically reached its maximum; while in the case of

* Third Report to the Alloys Research Committee. *The Institution of Mechanical Engineers*, 1895.

arsenic this is only attained when 34·7% of the total copper is reduced. With all the experiments thus considered the proportions of the contaminating metals are small. The presence of large proportions of some metals often affects notably the concentration of others; a marked example is afforded by the behavior of nickel when it occurs with arsenic.

Nickel and Nickel with Arsenic.—When present alone nickel does not appear to concentrate in bottoms. Only 8·0% of the total nickel is found in them when they contain 8·2% of the total copper. But when arsenic occurs together with nickel, and both are present in high proportions, they concentrate largely in the separated copper. Thus, with a separation of 19·3% of copper as bottoms, 77·7% of the total arsenic and 47·9% of the total nickel are found in them; and when 28·3% of copper is reduced, 83·9% of the total arsenic is concentrated in them. The concentration of silver is lessened by the presence of arsenic and nickel.

Presence of Metallic Iron.—With sulphides treated with an excess of iron, and 35·0% of the total copper separated as bottoms, there were concentrated in them 74·5% Ag, 83·5% Pb, 97·0% Sb, and 92·8% Au. There was a notable increase in the proportions of antimony and silver concentrated in the bottoms, when compared with those in the previous experiments in which iron was not used. Allan Gibb finally concludes as follows: "It is hence clearly evident that in the process of making 'best-selected' copper the proportion of copper separated as bottoms should not exceed 20·0% of the total copper in the furnace charge, a larger proportion having the effect not only of diminishing the yield of 'best-selected' copper from the spongy regulus, but also of impairing its purity."

The principle of the selecting process is not confined to the reverberatory; it may as well be carried out in the converter by blowing only a portion of the matte charge to metallic copper. This has been recommended by Paul David,* of France, who constructed a special converter for this purpose which he calls a "selecteur." Selecting has often been practiced involuntarily in the blast furnace when oxysulphide ores were the smelting problem. Such an instance is given in the table of analyses by the Boleo matte and copper of Santa Rosalia, Lower California.

In the figures given below are shown the composition of bottoms and regulus, or of metal and sulphide, representing instances of the three methods, none of which, however, was conducted so as to yield the most favorable results with regard to maximum elimination of impurities from the sulphide.

ANALYSIS OF BOTTOMS AND REGULUS.

Process.		Cu.	Pb.	Bi.	Sb.	As.	Te,	Se.	Ag.	Au.
		%	%	%	%	%	%	%	Oz. per ton.	Oz. per ton.
Reverberatory F. (Gibb)	Bottoms...	97·63		0·063	0·432	0·571			17·79	0·554
	Regulus...	74·45		0·012	0·033	0·187			5·54	0·0
Reverberatory F.....	Bottoms...	97·+	0·398	0·128	0·265	0·343	0·0022		173·50	1·18
	Regulus...	81·38	0·216	0·0244	0·0633	0·0411	0·0102		78·50	0·11
Converter	Bottoms...	97·+	0·0087	0·0056	0·0992	0·0260	0·0020		43·60	0·14
	Regulus...	81·40	0·0071	0·0012	0·0365	0·0081	0·0084		15·60	0·0
Blast F...	Bottoms...	97·74	0·3656	0·0041	0·2424	0·1852	0·0103	0·0016	59·10	0·13
	Regulus...	45·50	0·0526	0·0024	0·0317	0·0185	0·0269	0·0092	19·80	Trace.
Blast F. (Boleo).....	Bottoms...	91·65	0·1322	0·0030	0·0128	0·0197			6·00	Trace.
	Regulus...	61·54	0·0270	0·0008	0·0032	0·0013			2·20	Trace.

* THE MINERAL INDUSTRY, Vol. VIII.

IMPURITIES IN BOTTOMS, AND IMPURITIES IN REGULUS ON BASIS OF METALLIC COPPER. (*a*)

Process.		Proportion of Total Copper.	Pb.	Bi.	Sb.	As.	Te, Se.	Ag.	Au.
		%	%	%	%	%	% %	Oz. per ton.	Oz. per ton.
Reverberatory F. (Gibb)	Bottoms...	16·0		0·063	0·432	0·571	 \|	17·79	0·554
	Regulus...	84·0		0·0161	0·0443	0·2512	 \|	7·44	0·0
Reverberatory F	Bottoms...	(*b*)6·0	0·398	0·128	0·265	0·343	0·0022	173·50	1·18
	Regulus...	(*b*)94·0	0·2654	0·0301	0·0778	0·0505	0·0125	36·46	0·135
Converter	Bottoms...	44·0	0·0087	0·0056	0·0992	0·0260	0·0020	43·00	0·14
	Regulus...	56·0	0·0087	0·0015	0·0448	0·0100	0·0103	19·16	0·0
Blast F	Bottoms...	97·7	0·3656	0·0041	0·2424	0·1852	0·0103 \| 0·0016	59·10	0·13
	Regulus...	2·3	0·1156	0·0052	0·0697	0·0407	0·0591 \| 0·0202	43·50	Trace.
Blast F. (Boleo)	Bottoms...	45·7	0·1322	0·0030	0·0128	0·0197		6·00	Trace.
	Regulus...	54·3	0·0439	0·0013	0·0052	0·0021		3·57	Trace.

(*a*) The figure for copper has been taken at 100, thus implying a small error.
(*b*) This is an approximation, on the basis of the amount of gold in regulus.

By finding the quotient of each pair of the above figures for impurities, *i.e.*, by dividing the figure for bottoms by the figure for regulus, we obtain the relative concentration in the two products, or their relative purity. When the quotient is unit, the impurities are equally divided, *i.e.*, bottoms and regulus are equally impure. When the quotient is greater than unit the bottoms are more impure than the regulus, and when the quotient is less than unit the regulus is more impure than the bottoms.

RELATIVE CONCENTRATION OF IMPURITIES IN BOTTOMS.

Process.	Pb.	Bi.	Sb.	As.	Te. Se.	Ag.
Reverberatory F. (Gibb)		3·91	9·75	2·27		2·39
Reverberatory F	1·50	4·25	3·40	6·79	0·18	1·80
Converter	1·00	3·73	2·21	2·60	0·19	2·24
Blast F	3·17	0·79	3·48	4·55	0·18 \| 0·08	1·36
Blast F. (Boleo)	3·01	2·31	2·46	9·38		1·68

From my own results as given above, which are somewhat at variance with those of Allan Gibb, the following conclusions may be drawn: Lead shows small concentration in bottoms, or remains evenly divided when a small or moderate proportion of the original copper is reduced to bottoms. It shows great concentration in the latter when a large proportion of the original copper is reduced. Bismuth shows great concentration in bottoms when a small or moderate proportion of the original copper is found in them; it shows concentration in the regulus when a very large proportion of the original copper is converted to bottoms. Antimony and arsenic have greatly concentrated in the bottoms under all conditions; arsenic on the average more so than any other element. Tellurium and selenium show concentration in the regulus under all conditions. Silver always concentrates in the bottoms, and gold can only be found in traces in the regulus, except when a very small proportion of copper is reduced to bottoms.

Application of the Selecting Principle to the Extraction of Gold.—Allan Gibb found that with 14% of the total copper formed into bottoms, this would carry with it all the gold in the regulus. In this property of the copper, the selecting process has found its most important application, after having been entirely displaced by the electrolytic process for making pure marketable copper. In con-

nection with the concentration of gold, the selecting process is sometimes carried out in a reverse manner to that which has been described above; *i.e.*, auriferous metallic copper is smelted with sulphide ores, the metal being thereby reconverted into sulphide or regulus, or mineralized, as it was termed in England, and the gold thus concentrated in a reduced quantity of metallic copper, which may be regulated at will. Franklin E. Carpenter, in a valuable paper,* gives an interesting description of recent practice in smelting dry auriferous ores in the Black Hills of South Dakota, in which ample use was made of the principle of selecting. At first the ores were smelted in a blast furnace with barren pyrite and pyrrhotite, forming an auriferous matte or regulus. Often, however, metallic sows would form in the furnace and forehearth, composed almost of pure iron, which would retain much of the gold, and which would be reconverted to matte in a reverberatory. Later these same ores were smelted with copper ores from Butte, Mont., and thus an auriferous copper matte produced. Of the refining and disposition of these mattes the author says: "With iron matte, or matte very low in copper, there exists usually no problem, for it can be sold to the lead smelters. With high percentages of copper in the matte, however, there is a difficulty. It carries usually too much gold for the ordinary copper refineries, and too much copper for the lead refineries. At one time, about 1892-1893, we had a difficulty in disposing of our matte. We erected a lead-furnace, bought lead ores, and crushed and added the matte raw to the lead-charge. I found that the matte gave up nearly the whole of its gold to the lead. It still contained much silver. This matte was very different from the 'first matte,' and for want of a better name we called it after the Germans, 'herd-rohstein' (hearth matte), and added it to the matte-smelting charge; but owing to its containing lead, this treatment had not much success, as the lead was lost. The resulting bullion in the lead-process—very high in gold—was sold to the lead smelters. Fearing that they might decline to buy this, also, we erected one very large cupel, and two smaller ones, all of the English type, intending to cupel the bullion and add the resulting litharge to the lead-process. The whole process was borrowed from pyritic smelting as it is practiced in Kongsberg and in Russian Siberia, save that I used an ordinary American lead-smelting furnace and English cupels. The process, except as to the loss of lead in the matte-furnace, was promising, and, in the favorite language of the patent-right man, 'continuous.' The 'first matte' went into the lead-furnace, the second or hearth-matte back into the matte-furnace. The lead-bullion went to the cupels, and the litharge back to the lead-furnace. I do not know how this experiment would have ended; for our difficulties with the lead smelters were adjusted, and our relations with them ever afterward remained of the most pleasant character.

"The idea of refining, however, continued with me, and in connection with Mr. Arthur Howe Carpenter, I made many experiments, sometimes original, but more often along the lines laid down by the old metallurgists, who seemed to have covered, in theory at least, about everything. The most satisfactory process, and the one I should have followed had I remained at the works, was that laid down by Jars (I think in 1784) and quoted by Percy in the first edition of his *Metallurgy*.

* A paper read before the American Institute of Mining Engineers, August, 1900. NOTE.—Reference may also be made to the article on "Pyritic Smelting," by Franklin R. Carpenter, given later in this volume.

Afterward it was patented by the Vivians and others, and forms the first step, at least, of the Argo process. It will be remembered that our process was mainly for gold, and that copper-matte so high in gold was not desired by electrolytic copper refiners. Any process that would take out the gold and other 'impurities' would fit it for their process. The first step is the well-known copper-bottom process described for us by Dr. Pearce in his presidential address.* I proposed, not to try to separate the silver from the matte, but to proceed at once to the copper-bottom process, which I thought might be performed either by the French 'selecteur' method,† or as is now done at Argo. The resulting product—high-grade copper-matte—having given up nearly all of its gold and much of its silver, could be blown up to blister-copper and sold directly to the refiners. The copper bottoms I granulated, oxidized and cast back into matte, and effected a second 'selecting,' similar in all respects to the first.

"This selecting process is not wholly successful unless the copper-matte is impure; a certain percentage of lead being necessary. This lead is, of course, concentrated in the first bottom or 'selecting,' so that this carries a very large percentage of lead. In the second selecting, this is so increased that the resulting bottom may be at once cupelled—often requiring little or no additional lead. In fact, the first bottom can be directly cupelled, with the addition of lead, if so desired; the coppery litharge being, as shown by Samuelson,‡ even more fusible than the purer litharge of the ordinary methods. In practice, six parts of lead to one of copper give very satisfactory results. The coppery litharge forms a product which can be treated by the lead smelter, who has but to add it to his ore-charge—the lead going to the bullion, and the copper to the matte.

"It is unnecessary actually to repeat the selecting-process in all its details upon the first bottoms as above described. Equally good results, with much less trouble, can be had by simply returning the first bottoms, or 'plates,' to a reverberatory furnace, with additional sulphide material, and running them over and over until they are sufficiently reduced in size for final treatment by cupellation with metallic lead. The resulting coppery litharge is easily reduced to metallic lead and matte by treatment in a small reverberatory or 'softening' furnace, with galena, or iron pyrite; the lead may be used over and the matte is returned to the ore-smelting."

In the practice of the reverberatory process the elimination of the arsenic has attracted more attention than that of any other metal. It has already been shown that in ordinary calcination, at a comparatively low temperature, the elimination remains within low limits. The addition of charcoal, it has been stated by others, does not aid the process. It has also been shown that at higher temperatures when bottoms are formed, arsenic retreats to a large extent into the latter and thus evades actual elimination. Dr. Peters, in his excellent work already quoted, states that he was able to eliminate a large proportion of the arsenic by repeated smelting of the matte in the reverberatory with the addition of iron pyrites. Any one who has observed heep- or kiln-roasting has undoubtedly noticed the sublimation and condensation of arsenious oxide and arsenious sul-

* *Transactions of the American Institute of Mining Engineers*, XVIII., 55.

† Described in the *Engineering and Mining Journal*, Oct. 22, 1898.

‡ Percy, *Silver and Gold*, p. 513.

phide, indicating considerable elimination from highly sulphuretted ores. I have given this subject some attention by laboratory experiments, using as experimental material the Mexican leady matte, of which a full analysis is given in the table, and a pyrites containing 0·019% As, which was found to be practically completely eliminated in all the operations, and need not, therefore, be taken into account. My results will be found in condensed form below, and the conclusions drawn from them are as follows: In calcination to a "dead-roast" at such temperatures as are usually employed in this process (a low red heat), this matte, like the Anaconda matte, suffers but a small to a moderate elimination of its arsenic. The addition of iron pyrites up to a certain quantity aids the elimination of arsenic. The addition of increased quantities of pyrites has no beneficial effect. The addition of charcoal to the matte in calcination appears to increase the elimination of arsenic, which may be due, however, to an increased temperature rather than to the intrinsic properties of the coal. When the matte is first dead-roasted and then heated to the highest possible temperature of the muffle of a gas furnace, the increase in the elimination of arsenic over that in simple calcination is very small; *i.e.,* arsenical salts formed at the low temperature are not decomposed at the high one. When this matte is subjected to dead roasting at a very high temperature, and especially with the addition of moderate quantities of iron pyrites, practically all the arsenic is eliminated. To attain this end, however, it does not seem necessary to carry the oxidation to completeness. If, for instance, the matte with a moderate quantity of iron pyrites be brought into a porcelain crucible and covered with a porcelain lid, and be then subjected to the high temperature of the muffle to which the air has access, it will be found that after some time a part of the iron has been converted into magnetic oxide, that there is still the greater part of the matte present, and that a very large proportion of the arsenic has been eliminated. When the same matte is fused with a sufficient quantity of cupric oxide to expel all sulphur and to convert the copper into metal, the elimination of arsenic is much less than in the method before described. The conditions to expel the maximum amount of arsenic, therefore, seem to be the following: Very high temperature, oxidation, and prevention of the formation of metallic copper or bottoms. The function of the iron or sulphur of the pyrites seems to be less their action on the arsenic than their influence to retain the lastly named condition, and thus to enable the prolongation of oxidation. With a restricted access of air the same result seems to be achieved.

I have subjected the Anaconda mattes, which have been previously considered, to the reactions of this process on a laboratory scale, and have found that lead is eliminated to the extent of over 90%, bismuth from 30 to 40%, antimony 50 to 75%, arsenic up to 7%, tellurium none, and selenium completely. With mattes of varying impurity these results would undoubtedly vary accordingly; as we have already seen that a leady matte subjected to this reaction lost over 60% of its arsenic. For the latter material we have also seen that the elimination of the same element by partial oxidation was much greater. As compared with the ordinary reverberatory process, this process is equal to it as regards the elimination of lead and nearly so as to the elimination of bismuth and anti-

mony. It is superior as to the elimination of selenium; but much inferior as to that of tellurium and arsenic. When in the smelting of copper sulphide and copper oxide reaction has once set in through a sufficient heating from external source, the reaction will continue of itself. This process, therefore, distinguishes itself from any other by the fact that it can produce sulphur dioxide undiluted with furnace or atmospheric gases, which may make it particularly valuable in sulphuric acid manufacturing.

Elimination in the Nicholls and James Process.—This process is but a modified reverberatory process. It consists of two operations: (1) The calcination of matte or regulus, and (2) the smelting together of the calcined and raw products to produce metallic copper. We have already seen to what extent the elements are eliminated in calcination, and have found that for all but arsenic it is of little importance. In the Nicholls and James smelting process there is no access of free oxygen; the oxidation of sulphur and other elements being performed by the oxygen of the copper oxides, according to the following formulæ:

$$\text{I. } 2Cu_2O+Cu_2S=6Cu+SO_2.$$
$$\text{II. } 2CuO+Cu_2S=4Cu+SO_2.$$

CALCINATION AND FUSION TESTS WITH MATTE FOR ELIMINATION OF ARSENIC.

Matte taken. Grams.	Pyrite taken. Grams.	Operation.		Arsenic Found. %	Arsenic Eliminated. %
5		Raw		0·7690	
5		Calcined at low red heat	Extremes.	0·7370	4·2
5		Calcined at low red heat		0·6148	20·0
5		Calcined as above with 1 g. of charcoal		0·4538	41·0
5		Calcined at low red heat and very high afterward		0·5304	31·0
5	1	Calcined at low red heat		0·5496	28·5
5	2	Calcined at low red heat		0·5810	24·4
5	3	Calcined at low red heat		0·5982	20·9
5	4	Calcined at low red heat		0·5162	32·9
5	5	Calcined at low red heat		0·5482	28·7
5	10	Calcined at low red heat		0·5500	28·5
5	1	Calcined at low red heat and very high afterward		0·5304	31·0
5	5	Calcined at low red heat and very high afterward		0·6204	19·3
5	5	Calcined at low red heat and very high afterward		0·6444	16·2
5	0	Fused or roasted in open porcelain crucible, time, 30 minutes		0·0592	92·3
5	1	Fused or roasted in open porcelain crucible, time, 30 minutes		0·0616	92·0
5	5	Fused or roasted in open porcelain crucible, time, 30 minutes		0·0210	97·2
5	0	Fused or roasted in covered porcelain crucible at very high heat, time, 30 minutes		0·1268	83·4
5	1	Fused or roasted in covered porcelain crucible at very high heat, time, 30 minutes		0·0144	98·2
5	5	Fused or roasted in covered porcelain crucible at very high heat, time, 30 minutes		0·0640	91·7
5		Fused with 8 g. of cupric oxide at very high heat		0·02884	62·4

NOTE.—Each calcination was carried out to a dead roast.

The Elimination in the Converter.—Although the converter process has become the most important of all, and almost universal, the reverberatory process in its bearing on our subject has been discussed at considerable length. This has been done for the reason that all the principles involved in the chemistry of smelting and elimination of impurities are applied and can be followed in separate stages in the older process. In the converter these are concentrated into one operation and need no further consideration. It should, however, be mentioned that in converting we never have a low temperature as in the calcination of the reverberatory process; and that is one of the main reasons of the increased elimination of impurities in converting, especially of arsenic and bismuth. The fol-

lowing analyses and deductions from materials derived from the converter plant of the Montana Ore Purchasing Co., Butte, Mont., will serve well to illustrate the chemical working of the process:

	Cu.	Fe.	Pb.	Bi.	Sb.	As.	Te, Se.	Ag.	Au.
	%	%	%	%	%	%	%	Oz. per ton.	Oz. per ton.
Partial analyses of matte	52·0	20·88	1·2523	0·0418	0·0950	0·0634	0·0085	33·7	0·06
Impurities in copper			0·0517	0·0051	0·0533	0·0231	0·0078	70·6	0·12
Elimination of impurities			98	34	71	81	52		

ANALYSIS OF CONVERTER SLAG.

	SiO_2.	FeO.	Al_2O_3.	CaO.	ZnO.	Cu.	Pb.	Bi.	Sb.	As.	Te, Se.	S.
Per cent...	29·97	58·40	3·55	2·12	2·36	1.09	1·245	0·001	0·087	0·021	0·0	0·25

DISTRIBUTION OF ORIGINAL IMPURITIES CONTAINED IN MATTE.

	Pb.	Bi.	Sb.	As.	Te, Se.
	%	%	%	%	%
Amount of original impurities in copper	2	6	29	19	48
Amount of original impurities in slag	46	1	42	15	0
Amount of original impurities volatilized	52	93	29	66	52
	100	100	100	100	100

ANALYSIS OF CONVERTER FLUE-DUSTS.

	Cu.	Fe.	Zn.	Pb.	Bi.	Sb.	As.	Te, Se.	S.	SO_4.	H_2O.	Ag.
	%	%	%	%	%	%	%	%	%	%	%	Oz. per ton.
Near chambers	23·32	3·30	2·85	18·81	0·420	0·935	1·805	0·0026	1·34	34·46	10·87	18·2
Distant chambers	2·36	2·80	5·53	32·24	0·480	2·186	5·694	0·0054	0·0	36·15		6·4

From other data of my own, and such as Dr. Douglas* has published, the approximate average elimination of the various impurities that have been quantitatively determined in connection with the converter process may be given as follows:

AVERAGE ELIMINATION OF IMPURITIES IN THE CONVERTER.

	S.	Fe.	Zn.	Co.	Ni.	Pb.	Bi.	Sb.	As.	Te.	Se.
Per cent	99	99	99	99	37	96	97	71	81	40	47

These figures clearly demonstrate that the converter produces by far the purest copper, although the reverberatory stands on a par with it as regards the elimination of lead, and the Nicholls and James process as regards lead, and is at an advantage as regards selenium.

As has already been pointed out, nearly all copper now produced by any process is subjected to electrolytic refining, in order to produce a product of great electrical conductivity, and to save the precious metals. The elements which may be designated as not endangering the quality of electrolytic copper by their pres-

* *Transactions of the American Institute of Mining Engineers*, 1891, p. 511.

ence in the crude or anode copper are, sulphur, iron, zinc, manganese, cobalt, nickel and lead. Those which do endanger the qualities of the electrolytic copper are bismuth, antimony, arsenic, tellurium and selenium. It is, therefore, of value to remove the latter to the greatest possible extent in the process of smelting. Of all the mattes of which the composition is shown in the table, there are only three from which the converter and an ordinary refining would make good copper. If its product were not the best conductivity copper, it would no doubt be good rolling copper, or would be suitable for the manufacture of the best qualities of brass. What quality of copper might be produced by the converter from any of the mattes could readily be calculated, at least approximately, from the figures for the average elimination of the impurities in this process and from the composition of the mattes.

These figures would apply to the so-called gas-finish in converter-practice, and they would become largely modified by any change of such practice, as is shown by the following data from copper of the Boston & Montana Co.'s converter plant of Great Falls, Mont.:

	Cu.	Pb.	Bi.	Sb.	As.
	%	%	%	%	%
Copper and impurities in matte.....	49·34	0·0738	0·0337	0·1010	0·0480
Impurities in underblown charge.....		0·0087	0·0056	0·0992	0·0260
Impurities in normalblown charge.....		0·0069	0·0029	0·0546	0·0156
Impurities in overblown charge.....		0·0016	0·0015	0.0195	0·0072
Elimination in underblown charge.....		94	92	52	73
Elimination in normalblown charge.....		95	96	73	84
Elimination in overblown charge.....		99	99	90	93

In treating of the elimination of impurities from copper mattes, the precious metals have been but slightly touched upon, because, as has already been stated, they cannot properly be considered as being eliminated. Of course there is a loss of them in all operations, and every one would like to know just what that loss is, most eagerly of all, I have no doubt, the managers of the smelting works themselves; for this loss has probably not been determined anywhere with any degree of accuracy.

The impurities that are eliminated in any of the processes are found, as has also been shown, in the slag and in the flue-dust, or they disappear in the atmosphere. By the slags which are discarded they are permanently eliminated from the process. The flue-dusts, generally, are too rich in copper and precious metals to be discarded; they, therefore, re-enter the process periodically, contaminating the resulting copper in proportion to their quantity. In many cases, where the copper goes to the electrolytic refineries, this is no serious disadvantage. Occasions may arise, however, where it is desirous to keep the flue-dusts with their high content of impurities separate.

It has now been shown how Pb, Bi, Sb, As, Te and Se, as components of the mattes, are distributed in the products of reduction by the converter. In my paper on "The Electrolysis and Refining of Copper," in THE MINERAL INDUSTRY, Vol. VII., I showed how that portion of the same elements which follows the metallic copper becomes distributed and concentrated in the electrolytic tank-residues and in the electrolyte; from which products the more valuable elements

could readily be recovered. Little attention, however, has so far been paid in this country to these minor elements, probably because the profits on copper and the precious metals have been large, and because the presence, in many instances, of other valuable elements has been unknown to the practical workers of the material. As an industry becomes more and more perfected, and as educated engineers, metallurgists, and chemists take the place of routine practicians, the principle—that none of nature's treasures shall be wasted if they can be saved with any profit at all—will in future become more extensively applied. It may, therefore, be appropriate to add a few remarks on such valuable metals as nickel and cobalt, when present in small quantities as companions of copper.

I have found that their copper could be conveniently lixiviated, and the residues thus rendered a fit material for the lead smelters. The subjoined table will illustrate this:

SOLUBILITY OF COPPER CONTAINED IN FLUE-DUST.

Flue-Dust.	Total Copper.	Copper Soluble in Water.	Of the Remaining Copper Soluble in Hunt & Douglas's Solution.	Copper Insoluble in the Two Reagents.
	%	%	%	%
Matte-calcining	18·74	17·66		
Matte-smelting	36·40	12·26	18·74	5·40
Converter, near chambers	23·32	11·63	8·37	3·32
Converter, distant chambers.	2·36	2·31		

There can be no doubt that practically all the nickel and cobalt, occurring with copper sulphide ores, will go into the matte. From the latter more than one-half of the nickel will go into the metallic copper, both in the reverberatory and in the converter process, and will thus enter the electrolytic refinery, where it will become dissolved in the electrolyte. In a constant quantity of the latter it concentrates with increasing quantities of copper treated, and may be separated by crystallization or metallic deposition. Such portions of the nickel as are slagged in ordinary refining of crude copper would, like the copper that has been slagged, return to the original circuit. The cobalt that enters the mattes is practically all lost by slagging in any of the reduction processes, from which slags there is little chance of its profitable recovery. When oxidized ores or oxysulphide ores of copper containing cobalt are smelted in a blast furnace, the cobalt will be found in the black copper produced. I have shown two notable instances of this kind in this paper, *i.e.*, the black copper of the Compagnie du Boleo of Santa Rosalia, Mexico, and the Chili bars. Taking the latter as an example, they contain about 0·14% Co. When this kind of copper is refined, at least 2% of the copper is slagged, carrying with it nearly all of the cobalt. Assuming that in smelting this slag in a blast furnace all the copper and all the cobalt were reduced to a metallic state (which is probably very near the truth), we would then obtain a copper containing 7% Co. For the same product of the Boleo copper we would arrive at the high figure of 24% Co. Such copper directly cast into anodes and subjected to electrolysis would yield a highly cobaltiferous electrolyte, from which the cobalt could be regained as readily as nickel.

The Raritan Copper Works.*

By Lawrence Addicks.

[Before proceeding with the description of the plant, I wish to acknowledge my indebtedness to the heads of the various departments for valuable assistance rendered in the preparation of this article.]

The Raritan Copper Works, in its location at Perth Amboy, N. J., possesses unusual advantages for the economical refining of copper. The transportation facilities are such that the most favorable freight rates, both domestic and foreign, are obtainable and the proximity of New York allows the lowest prices on supplies to be procured. Spurs from the Pennsylvania Railroad, the Central Railroad of New Jersey and the Lehigh Valley Railroad, run directly into the yards of the works, and a private line of lighters is maintained from the company wharf, a short distance from the furnace building, to New York by way of Staten Island Sound. The lighters afford a cheap means of placing the refined product alongside outward-bound vessels at New York and the competition among the different railways precludes the possibility of the company's ever being placed at the mercy of a single line. There is sufficient depth of water at the wharf to allow large vessels to load and unload directly at the works, should it be found desirable.

The plant was designed for a maximum monthly production of from 10,000,000 to 12,000,000 lb. of cathode copper in the tank house and from 15,000,000 to 18,000,000 lb. of refined copper from the furnaces. The output of precious metals varies with the character of material treated, but may be stated as 300,000 oz. of silver and 5,000 oz. of gold per month. A very wide range of raw material is treated, about the only requirement being that the copper content shall be equal to that of good blister copper. The excess of furnace capacity over tank house capacity makes it possible to treat a considerable quantity of outside cathodes. Anodes from outside sources also are more or less handled.

General Plan.—The general arrangement of the buildings and railroad connections is shown on the accompanying ground plan (Fig. 1), which is self-explanatory. The standard gauge tracks connecting with the several railway systems are indicated by heavy lines, while the narrow gauge tracks of the industrial railroad, as it is called, are distinguished by light lines. This railroad is equipped with two locomotives and a large number of iron flat cars of a capacity of 10 tons each, and it binds all the buildings together with a network of tracks. All incoming copper bullion is unloaded from the freight cars directly on these small ones and taken to the storage building where it is weighed without being removed, in drafts of about 15,000 lb. Ample yard tracks are provided so that such material as is not for immediate use may be temporarily stored on the cars, thus avoiding subsequent rehandling.

The greatest care is used to obtain accurate weights. Two scales are provided and all material is weighed twice. Furthermore there are two weigh-masters who keep independent records, while a third man checks the number of pieces. The scales were installed by the Fairbanks Co., and their representative makes weekly visits to the works to examine and adjust them. For further

* The Raritan Copper Works reserves the right of independent publication for the drawings and photographs included in this article.—Editor of The Mineral Industry.

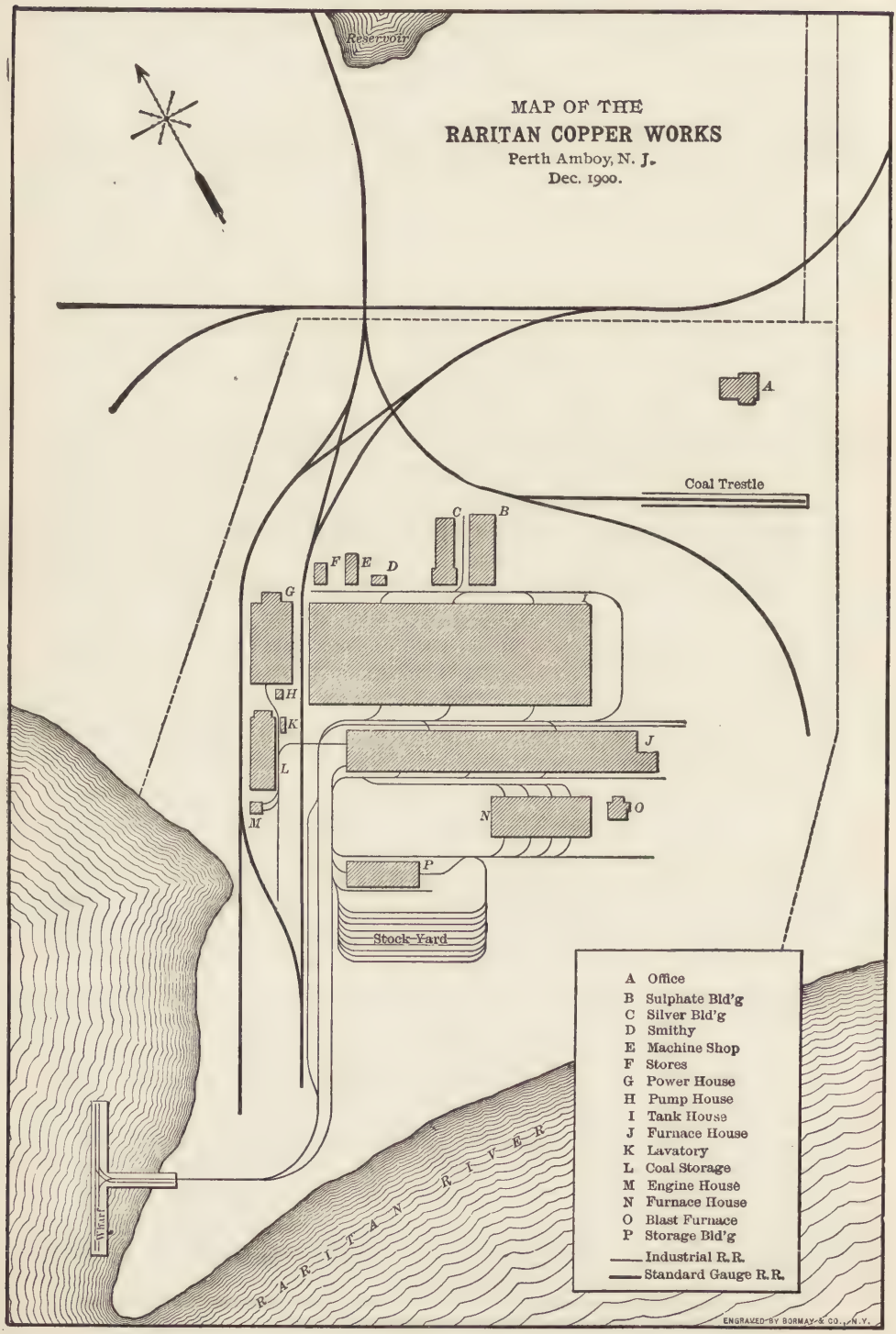

Reservoir
MAP OF THE
RARITAN COPPER WORKS
Perth Amboy, N. J.
Dec. 1900.
A
Coal Trestle
C
B
F
E
D
G
I
H
K
J
L
M
N
O
P
Stock Yard
A Office
B Sulphate Bld'g
C Silver Bld'g
D Smithy
E Machine Shop
F Stores
G Power House
H Pump House
I Tank House
J Furnace House
K Lavatory
L Coal Storage
M Engine House
N Furnace House
O Blast Furnace
P Storage Bld'g
Industrial R.R.
Standard Gauge R.R.
R A R I T A N R I V E R
W. Wharf
ENGRAVED BY BORMAY & CO., N.Y.

FIG. 1.

reassurance that they are in perfect adjustment a car loaded with standard weights is run on several times a day. Heavy sampling drills and a coffee-mill are also provided in the storage building.

The works proper, shown by the dotted fence line on the map, cover about 45 acres. The various buildings are grouped about the tank house as a center and all are so arranged that future extensions may be made with the least possible expense and inconvenience. A coal storage building is conveniently placed near the power house, and a coal trestle to supply the furnaces is located at the opposite side of the grounds.

The general use of steel construction throughout the plant, the thorough fire protection and the universal application of labor-saving machinery, are noteworthy features. The three furnace buildings are entirely of metal and need no special fire protection. The tank house has a steel skeleton with brick curtain walls and is protected by a thorough system of automatic sprinklers and eight inside hose connections. The other main buildings are protected by sprinklers. The coal storage building is provided with a number of thermostats buried in the coal heaps. For fire service an Underwriter pump of a capacity of 1,000 gal. per minute is kept in constant readiness to be thrown on full head at an instant's notice. The water supply consists of an 8-in. city main, a 24-in. line from the river, two wells and a reservoir. In an emergency a portion of the regular pumping system may also be pressed into fire service. A number of fully equipped hose houses and a thoroughly organized fire department complete the protective measures.

In passing it may be of interest to state that the ground was broken for the erection of the first building on August 1, 1898, and the current was turned on in the tank house March 23, 1899, an interval of less than eight months.

Office Building.—The office building is two and one-half stories high and about 75×90 ft. Here are located the general offices, the drafting room and the chemical and physical laboratories. The chemical laboratory is divided into three rooms, the assay room, the balance room and the general laboratory. The assay room is equipped with three gas muffle furnaces, a gas crucible furnace, a rolling machine, a cupel machine, pulp balance, bucking board, etc. The balance room contains a set of five gold, analytical and pulp balances, supported on a special foundation to avoid vibration. The general laboratory, which is about 20×35 ft., is furnished with the customary gas, water, electricity, suc-

Frequency.	Material.	Determinations.
Twice daily..	Blast-furnace slag.....	Cu.
Daily	Electrolyte (*a*).....	Cu, Acid, Sp. Gr.
	Copper bullion.....	Cu, Ag, Au.
	Anodes	Cu, Ag, Au.
	Blast-furnace pigs.....	Cu, Ag, Au.
Weekly.....	Cathodes	Cu, Ag, As, Sb.
	Electrolyte.....	Cu, As, Sb, Cl.
	Slimes	Cu, Ag, Au.
	Silver slabs.....	Ag, Au.
	Silver slag.....	Cu, Ag, Au, Pb.
	Fine silver.....	Ag.
	Fine gold.....	Au.
Occasionally.	Blister slag.....	Cu, Ag, Au.
	Refinery slag.....	Cu.
	Blast-furnace charge..	Cu, Ag, Au, SiO_2, Fe, CaO.
	Cement copper.....	Cu, Ag, Au.

(*a*) Performed at laboratory in tank house, but included here for the sake of completeness.

tion, hoods, etc. A unique feature is the use of electric heaters as hot plates in the hoods. On the preceding page is tabulated the routine work of the laboratory.

There are also special determinations occasionally made, as analyses of coal, water, etc., and the copper, arsenic and antimony contents in wire bars in the event of a low conductivity report by the physical laboratory, but these are of comparatively infrequent occurrence. For details of the methods of analysis employed, the reader is referred to the article on copper analysis by Titus Ulke,* the methods there described agreeing closely with those employed here.

The physical laboratory is equipped with a Queen conductivity bridge, a 6,000-lb. Riehlé tensile machine and a 500-lb. Riehlé torsional wire testing machine. Daily tests are made of the conductivity of each lot of copper produced by the refining furnaces, whether ingots, wire bars, or cakes. The bridge

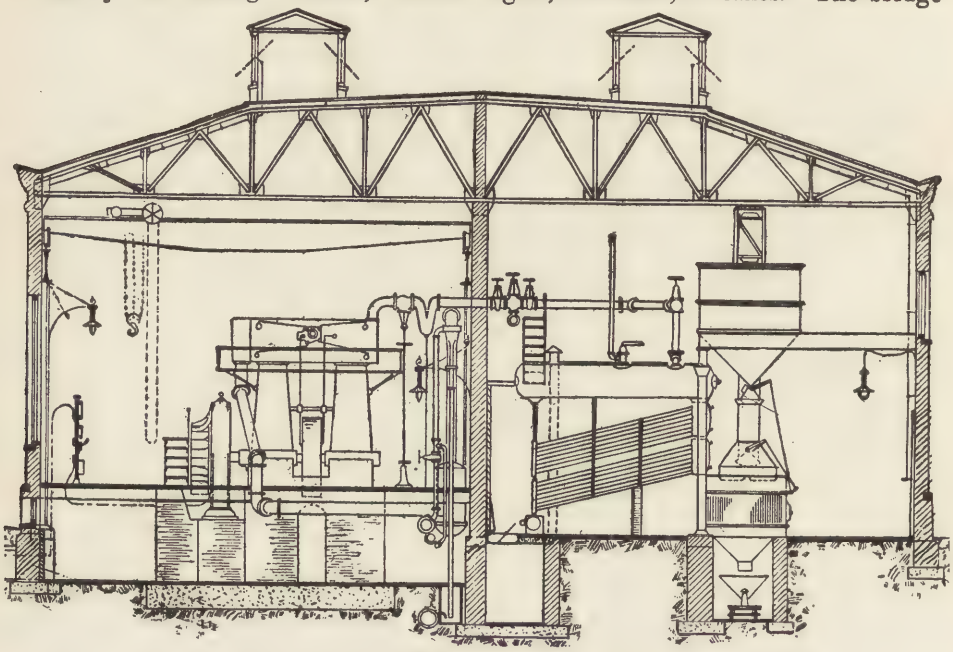


FIG. 2.—CROSS SECTION OF POWER HOUSE.

is checked each day against a standard. No. 12 B. & S. annealed wire is used for these conductivity tests; it is drawn in the shops from small sample bars taken from each charge. The written approval of the physical laboratory is required before any lot is allowed to leave the works.

Power House.—The power house is of modern design, built of brick and steel. It is divided by a central longitudinal brick partition into boiler and engine rooms. The general arrangement is clearly shown in the sectional drawing (Fig. 2). The building is thoroughly fire proof and in this connection it may be noted that the engine room floor is constructed on the Ransome system of cement throughout. A basement 9 ft. in the clear is provided beneath the engine room.

* *Engineering and Mining Journal*, Dec. 16, 1899.

The boiler room contains the boiler equipment only, consisting of eight 400-H.P. and two 200-H.P. Babcock & Wilcox water tube boilers. These are set in pairs with a passageway between each battery for the convenient blowing of tubes and cleaning of dust chambers. The furnaces are of the Murphy automatic stoking type. Directly beneath them is an ash tunnel running the length of the building; through this tracks are laid for a side-dumping steel car. Under each furnace is a steel hopper, the dimensions of which correspond to the capacity of the car, furnished with a sliding gate at the bottom. When the car is placed in position, this gate is opened, the ashes are dumped and the car is pushed through the tunnel to a hydraulic lift at the south end of the building, raised to grade and run out to the lowlands for dumping. Over the furnaces is a coal hopper of 393 tons' capacity, extending the length of the boiler room, with a discharge nozzle over each feeding magazine. At the end of each nozzle is a swinging gate with lever and rod connection extending down to the front of the furnaces within easy reach of the firemen. Directly beneath each nozzle is hung a heavy sheet iron chute, of 13 cu. ft. capacity, at the lower end of which is another swinging gate controlled with lever and rod as before. These chutes and levers are shown in the photograph of the boiler room (Fig. 3). There are two furnaces to each boiler and one double and two single magazines to each pair of furnaces. The upper gate levers are connected to a counter in such a manner that the number of chutes of coal used for each boiler is registered, thus allowing the coal consumption readily to be computed.

The coal is handled mechanically throughout its entire course, being dumped from the cars in which it is shipped into a hopper, then taken by a drag conveyor, screened, the coarse lumps crushed, recombined with the screenings and elevated to the tower of the coal storage building just south of the power house. From this tower it may be conveyed either to the bins of the coal storage building or directly to the hopper in the boiler room. The space beneath each boiler where the grates and ash pits are usually placed, is used entirely as a combustion chamber and for the collection of the heavier ash and soot which is carried through from the furnaces. The smoke flue is built as a tunnel parallel with the ash tunnel and leads to a brick stack 175 ft. high, at the south end of the building. There are individual dampers arranged for hand control and a main damper governed by a Spencer damper regulator. The north boilers are used for electrolytic service, while the three south boilers are used independently for supplying steam for solution heating in the tank house and for operating the general service pumps and the light and power engines. These latter boilers are operated at 125 lb. and the former at 170 lb. gauge pressure.

The illustration of the power house (Fig. 2) and the photograph (Fig. 4) show the general arrangement of the main piping. The steam header is shown in section near the division wall. The valves allow a boiler to feed its own engine directly or to supply the main header in parallel with the other boilers as occasion may demand. With this system it is possible to repair the entire steam header without interruption of the service or in turn to repair any one of the steam mains without discontinuing the service for more than one unit. A separator is inserted between the header and each throttle valve. The engines

for the electrolytic service, five in number, are vertical, cross-compound and condensing, running at 150 revolutions per minute, each direct-connected to its generator. The different generators vary slightly in capacity, but the largest, built by the General Electric Co., deliver 4,500 amperes at an efficiency of 93·5%. The engines for supplying light and general power are horizontal, tandem-compound, running at 265 revolutions per minute, with generators direct-connected. All of the engines were built by the Ball & Wood Co. Efficiency tests of the vertical Corliss engines showed an economy of from 13·4 to 13·7 lb. of steam per I.H.P. per hour. The exhaust piping of the engines leads from the gallery down past the generators, through the floor to Berryman feed water heaters and thence to Bulkley ejector condensers. Each engine has its independent intermediate heater and condenser. The boiler feed water passes from the city main through a meter in the north end of the power house basement into a main running the full length of the building and tapped at each of the Berryman heaters. A parallel main receives the discharge from the heaters and carries it to a Cochrane open heater set directly above the feed pumps at the south end of the building. The exhausts from the light and power engines, and boiler feed and general service pumps are taken into this heater. The Berryman heaters deliver the feed water at 123°F. and the Cochrane heater raises this temperature to about 210°F. The feed water is carried into the feeding main by duplex, tandem-compound Snow pumps. The branch for each boiler is provided with a Worthington hot water meter and a specially graduated throttling valve. Suitable thermometer wells and boiler oil injectors are placed in each boiler feed pipe within easy reach and control of the engineer—the feed pipes do not pass through the division wall into the boiler room until after leaving the hot water meters. A valve in the feed line is also placed in the engine room so that the engineer may control the supply of water if he so desires. Water column, gauge cocks and steam gauge for each boiler are placed along the division wall on the engine room side, the piping leading directly through the wall to the drums of the boilers. There are also draft and pyrometer tubes in this wall at the rear of each boiler. In this way the engineer has the boiler-performance entirely under his observation and control without going into the boiler room.

At the extreme south end of the power house is the pumping plant. It consists of two centrifugal pumps which take water for condensing purposes from a well fed by the river; two 24-in. stroke, 3,000,000 gal. compound duplex pumps which are used expressly for supplying bosh water to the copper furnaces on a return system including the reservoir; a 350,000-gal. compound duplex pump used for supplying water for general purposes about the works; and the simple, duplex, Underwriter pump, before mentioned, which ordinarily supplies a number of hydraulic lifts. Two Westinghouse 9·5-in. air pumps supply air at 70 lb. pressure for cleaning generators, handling oil, acid, etc., and for operating pneumatic hoists.

The oiling system for the entire plant is a modification of the usual gravity system. A reservoir is placed at one end of the engine room directly beneath the roof and is connected by suitable piping with the sight feed and controlling



Fig, 3. Boiler Room of the Power House, showing the Automatic Stoking Furnaces.

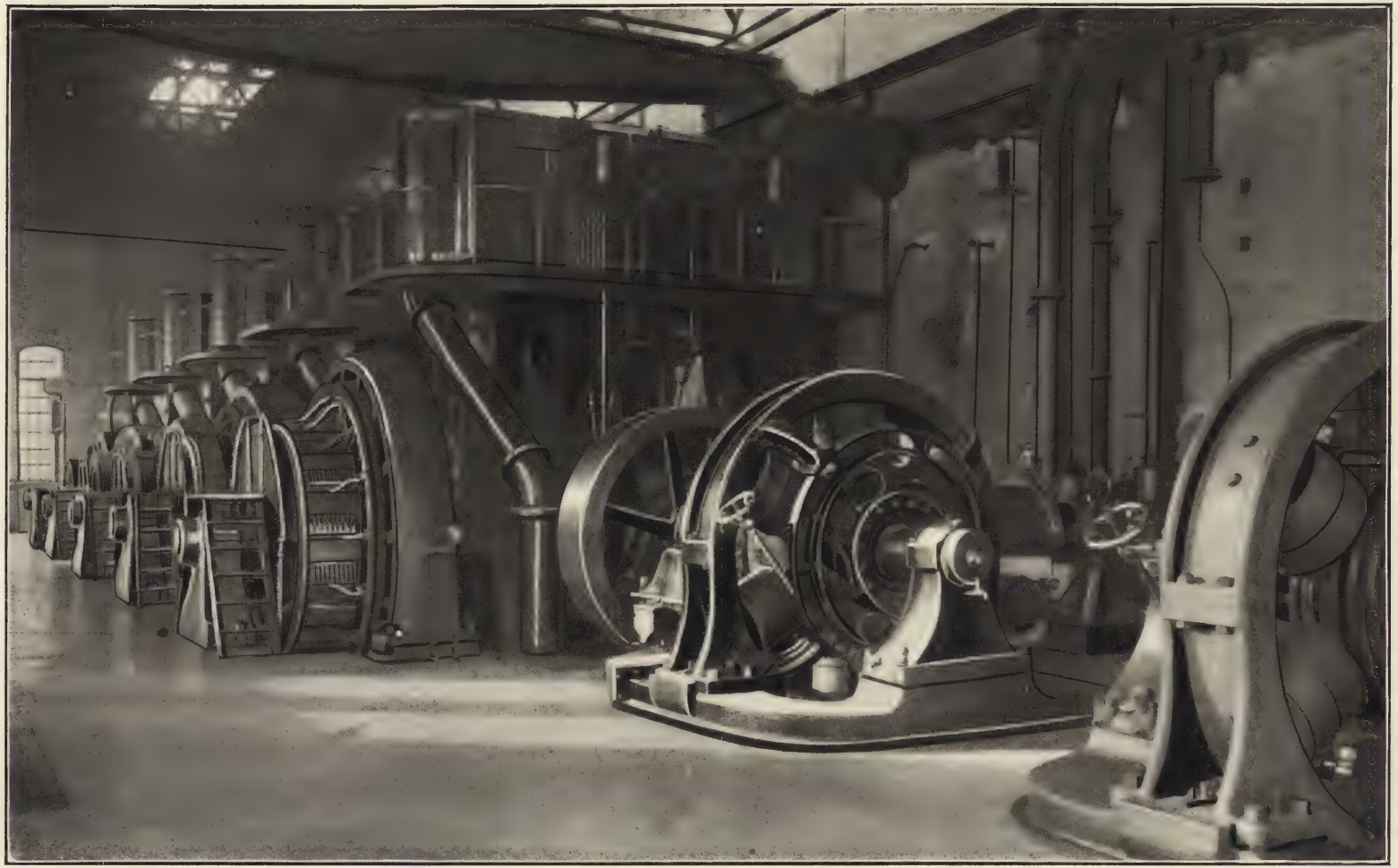


Fig. 4. Power House.

valves which distribute oil to the various bearings. All of the valve motion mechanism is lubricated with grease from compression cups. The engines are specially fitted with oil ways, collecting rings and guards, and the waste oil is carefully caught and piped to a fire-proof oil room in the basement. In this oil room there are two sets of filters and a receiving tank from which the overhead tank is periodically filled. Compressed air is used for refilling the overhead gravity tank and a counter attached to a float registers the number of tanks of oil used. The valves and pistons of the engines are lubricated by means of Sterling, Jr., pumps. There is a pump connected with each admission

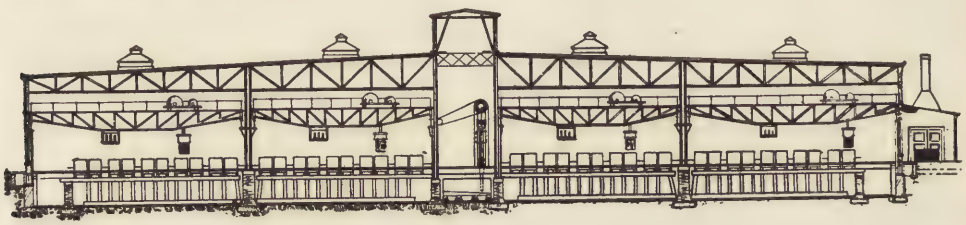
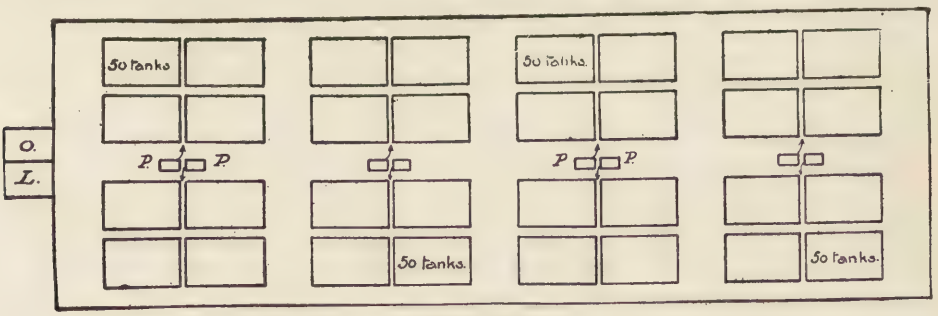


FIG. 5.—CROSS SECTION OF TANK HOUSE.

valve, operated by the exhaust valve mechanism in such a manner that a minute quantity of oil is injected into the steam just prior to its admission to the cylinder at each stroke.

Tank House.—The electrolytic plant is in a single building approximately 200×600 ft. The use of a steel skeleton, carrying the loads, and brick curtain walls, and the 7 to 8 ft. of head room in the basement are noteworthy features in the construction. The type of building is shown in the illustration (Fig. 5) and the photograph (Fig. 6). Thorough lighting and ventilation are supplied by an immense number of windows, a large high monitor and a series of ven-



Ground Plan.
O, Office. *L*, Laboratory. *P*, *P*, Pumps. Total number of tanks, 1,600.

FIG. 7.—TANK HOUSE.

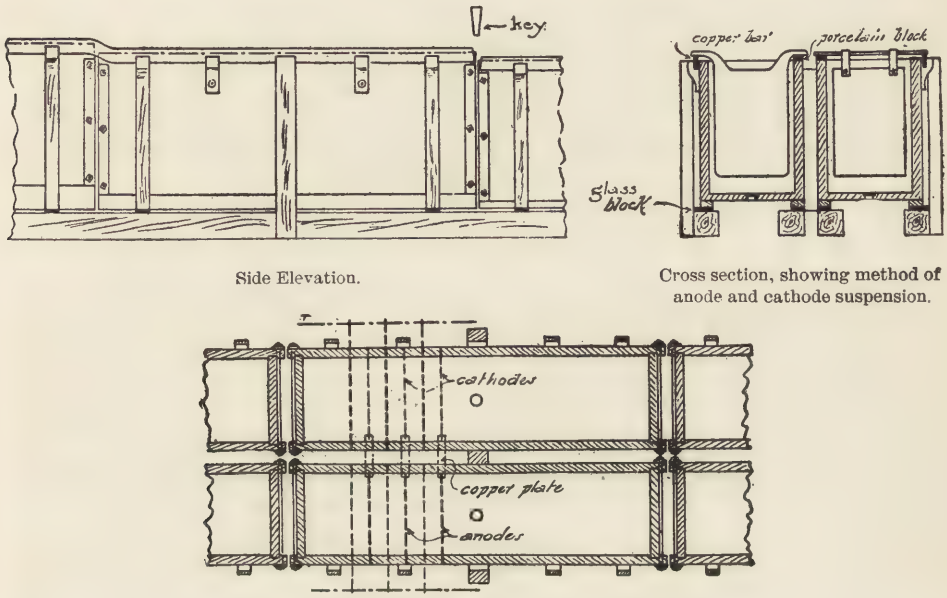
tilating skylights. The main floor is made very heavy and can support a loaded train in connection with the industrial railroad. The basement is floored with a 6-in. layer of tar concrete which has proved very satisfactory in withstanding acid and trucking. There is a 5-ply tar and gravel roof, the planking of which is carried on steel trusses. The general ground plan is shown diagrammatically

in Fig. 7. An office and laboratory are provided at one end while the main floor space is given up to the 1,600 depositing tanks. The liberating tanks, 32 in all, are in small additions built on the north side. Emery wheels, punches and shears are placed along the end walls, and the solution pumps are situated in the main longitudinal aisle. Tunnels are provided from the basement to the power house and silver buildings. Four electric cranes equipped with a special appliance for handling electrodes, run the length of the building, each commanding 400 tanks. For convenience in description the tank house may be considered, first, from the point of mechanical operation, second, from that of electrical supply and, third, from that of distribution of electrolyte.

Operation.—The regulation multiple system is in use, the tanks being electrically in series and the electrodes in each tank in parallel. This necessitates the apportionment of a certain number of tanks as cathode-forming or "stripping" tanks. These, 180 in all, are divided between the two end sections, giving ready access to the special machinery along the end walls. The cathodes in these tanks are rolled plates of pure copper, 0·156 in. thick, the surfaces of which have been smeared with tallow which is kept fluid in steam-jacketed pots. These are used as a basis on which to form the thin cathode sheets for use in the regular depositing tanks. The edges are protected from deposition by grooved wooden strips which are slipped on before the plates are put in position. After remaining in the stripping tanks 36 hours, they are removed, the wooden edges knocked off and the thin sheet of deposited copper peeled from each side of the plate, the presence of the tallow having prevented any firm adhesion of the surfaces. The entire work of removing, stripping and replacing a plate occupies but a few moments. The thin cathode sheets are taken to the shearing and punching machines where two thin copper loops are riveted on. They are then flattened carefully out by beating with wooden paddles and hung in the depositing tanks from copper rods which are flattened at one end to prevent rolling. At the end of seven days the cathodes are removed, a tank full at a time, by the crane and dumped on the floor in one of the main cross aisles. The rods are taken out and the cathodes piled on cars of the industrial railroad to be taken to the furnaces. The shape and method of support of the electrodes may be seen in the drawing illustrating the details of tank construction (Fig. 8). The anodes are brought into the tank house on cars and hung in frames made of structural iron, which are designed to place the anodes in the same relative position that they are to occupy in a tank. When a sufficient number to fill one tank have thus been hung, the traveling crane picks them up without touching the frame and carries them to the tank in question, lowering them directly into place without any intermediate handling by the men. The crane is shown in action in the photograph of the tank house (Fig. 6). Each anode weighs about 400 lb. and as there are 22 to a tank, the load weighs between 4 and 5 tons. In addition to the cranes, runways are provided over each separate row of tanks, along which trolleys travel that carry differential blocks for the convenient handling of single electrodes. These find constant use in connection with the stripping tanks. The anodes remain in the tanks 43 days on an average, when they are taken out, scrubbed and sent back to the anode furnaces as scrap. By careful

reworking in the tanks all anodes the condition of which, on removal, warrants the labor of rehandling, the percentage of this scrap returned to the furnaces is kept down to about 9%. The slimes are removed but once in three months. Then the tanks are emptied of solution one at a time by means of steam siphons. The slimes are sluiced through an outlet in the tank bottom into barrels mounted on trucks in the cellar below.

Electrical Supply.—Electrically, the tank house is divided into units of 400 depositing and 8 liberating tanks each. These 408 tanks are all connected in series and form the load of one of the large generators in the power house. There are 22 anodes and 23 cathodes in multiple in each tank. The arrangement of tanks in pairs with cross connections, as shown in the diagram of electrical connections (Fig. 8), combines convenience in handling with economical use of



Side Elevation.

Cross section, showing method of anode and cathode suspension.

Plan, showing electrical connections by the dashed lines.

FIG. 8.—DETAILS OF TANK CONSTRUCTION.

copper in conductors and minimum impairment of efficiency in event of short circuit occurring between a pair of electrodes. The main conductors are 1·25×4 in. bar copper, carrying about 4,000 amperes. The connections between paired tanks are made by means of strips of copper. All contact resistances are kept as low as possible by the liberal use of emery. This gives a current density of 15 amperes per sq. ft. of cathode surface, the end electrodes being credited with but one active side each. During cleaning, a tank is short circuited by use of the wedge or key shown in the drawing (Fig. 8). The conductors are supported by five clamps on each tank, three of which are carried down to the stringers below. The tanks are insulated from the building with the greatest care, glass blocks being used under all supports, and the main floor having a clearance of

several inches. Bulging at the sides is prevented by the alley-way floors and iron braces on the outside tanks.

Distribution of Electrolyte.—Each of the electrical units mentioned above is divided into two circulations, each consisting of 200 depositing tanks, four liberating tanks, a solution well and a pump. Thus there are, in all, eight entirely independent circulations. The ground plan of the tank house (Fig. 7) shows the way in which these units are placed in the building, each pump supplying four of the 50-tank squares as indicated by the arrows. These units are terraced in each direction as shown in the diagram (Fig. 9). The solution is carried

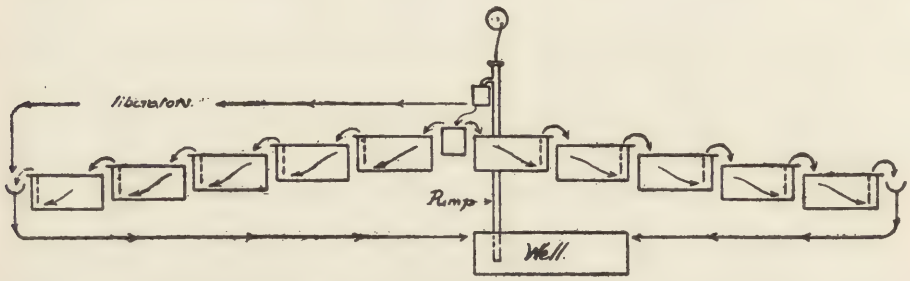


FIG. 9.—SYSTEM OF CIRCULATION OF ELECTROLYTE.

from the supply box at the pump along a main and supplies the tiers in multiple, so that each ounce of solution does duty in five tanks in series before being returned to the solution well to be pumped up again. The rate of circulation is controlled by the throw of the pump, which is of the plunger type; at the rate maintained, all the solution in a tank is replaced about every hour and three-quarters. The distribution is governed by valves at the crest of each tier. The spouts from tank to tank take the solution from the bottom of one tank and deposit it on the top layer of the next, thus maintaining a uniform density. The tanks are lined throughout with 8-lb. lead, the launders with 6-lb. and the solution well with 14-lb. A certain portion of the solution is taken from the supply box at the pump through a small pipe leading to the liberating tanks, and thence returned to the well. These liberating tanks serve to regulate the copper content of the electrolyte. They are identical with the depositing tanks in construction and operation except that lead anodes are used. Their location, in small additions to the main building with special ventilators, prevents the excessive contamination of the tank house atmosphere due to the fumes here given off. The solution is maintained at a mean temperature of 120° F. by steam coils in the wells. On those circulations which include stripping tanks the solution is cleansed of tallow by being forced under an inverted dam. The tallow is removed from time to time at the entrance side of the dam where it collects. A circulation may use the same solution a number of months before it becomes sufficiently foul to give any trouble; when this finally occurs a portion is run off into a storage well in the cellar, and replaced by fresh solution. When a sufficient quantity of foul solution has accumulated in this well it is run over to the sulphate building; its subsequent treatment is described later in this article. The

following partial analyses of a working solution and the copper deposited from the corresponding bath are taken from a regular assay report of recent date:

	Cu. %	As. %	Sb. %	Ag. Oz. per ton.	Free H_2SO_4 %	$CuSO_45H_2O$. %	Sp. Gr.	Mean Temp.
Electrolyte .	4·25	1·1601	0·0295		9·12	16·79	1·220	117° F.
Cathode	99·94	0·0013	0·0015	0·30				

Solutions more impure than this are constantly in use.

When slimes are to be removed, the tanks in question are cut out of service, the circulation being stopped by closing the valves on the individual supply pipes at the crest of the cascade and the current being shut off by short circuiting. The traveling crane then removes the anodes, a tankful at a time, and similarly the cathodes. The solution in the lowest pair of tanks is then emptied into the launder through a steam siphon. The plug in the bottom of the tanks being pulled out, the slimes are sluiced out with the residual few inches of solution

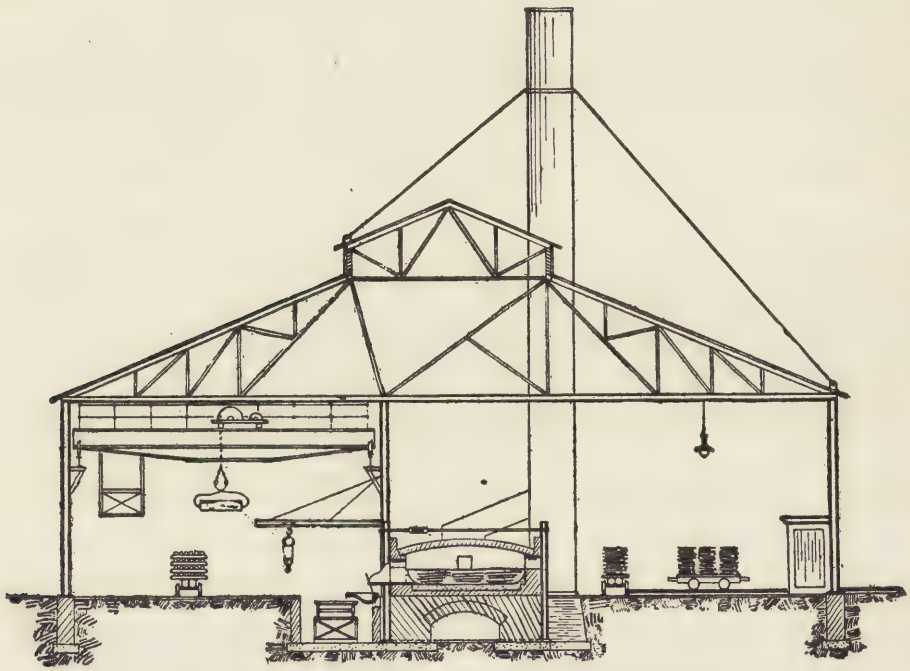


FIG. 10.—SECTION THROUGH FURNACE BUILDING.

into the slime barrels in the cellar below. The plug is replaced and the solution in the next pair of tanks siphoned into the pair just cleaned and the new electrodes placed in position by the crane, and so on. The circulation is stopped in 10 tanks at a time while cleaning, the current, however, being shut off from but four at a time. The slime buggies are pushed through the tunnel into the basement of the silver building and their treatment will be described further along in this article.

Furnace Buildings.—There are three furnace buildings, shown on the ground plan (Fig. 1) at *J*, *N* and *O*. The first is about 80×600 ft. and contains four

50-ton anode furnaces and five refining furnaces of the same capacity. The second building is 80×200 ft. and contains four 25-ton refining furnaces. The third building is the blast furnace building, which will be considered under a separate heading. These buildings have steel skeletons, corrugated iron sides and roof, and checkered cast-iron floor plates. The nine 50-ton furnaces are equipped with mechanical conveyors for the rapid casting of anodes in the case of four furnaces and wire bars in the case of the others. One 25-ton furnace is furnished with a special conveyor for casting cakes. The three others are used for making ingots and moulds by hand ladling and one of them has a pit for making shot copper. A section of the large furnace building is shown in Fig. 10 and plan and sections of a 50-ton furnace are shown in Fig. 11. The charging side of the building being next to the tank house allows a ready handling of cathodes to the refining furnaces. The tracks of the industrial

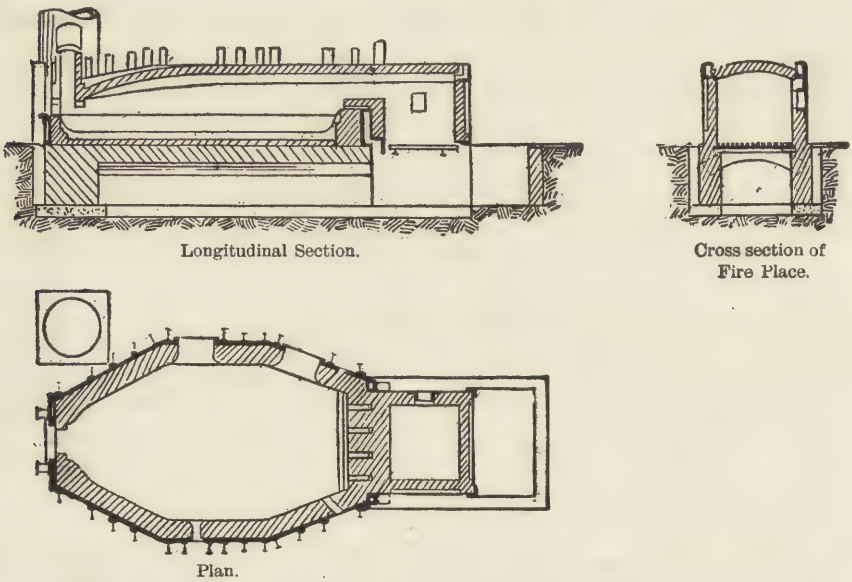


FIG. 11.—DETAILS OF THE 50-TON COPPER-REFINING FURNACE.

railroad run the length of the building on both sides. On the pouring side there is a traveling crane and a number of small jib cranes. At one end of the building is a ladle drying furnace where the clay linings of ladles are quickly and cheaply baked.

The refining process presents nothing worthy of special note, the customary rabbling and poling being followed. The blister or anode furnaces pour a daily charge of up to 150,000 lb. each, which has been mixed to produce anodes containing from 100 to 120 oz. of silver per ton. The daily output of the wire-bar furnaces reaches 120,000 lb. each.

The mechanical conveyor of one of the wire-bar furnaces is shown in the photograph (Fig. 12). The molten copper is received in a ladle placed directly below the tap hole launder, and is thence delivered to moulds brought successively into position by a table conveyor. The ladle is of sufficient size to hold the copper



Fig. 6. View of Tank House, showing the arrangement of the tanks and electrodes, and overhead crane.

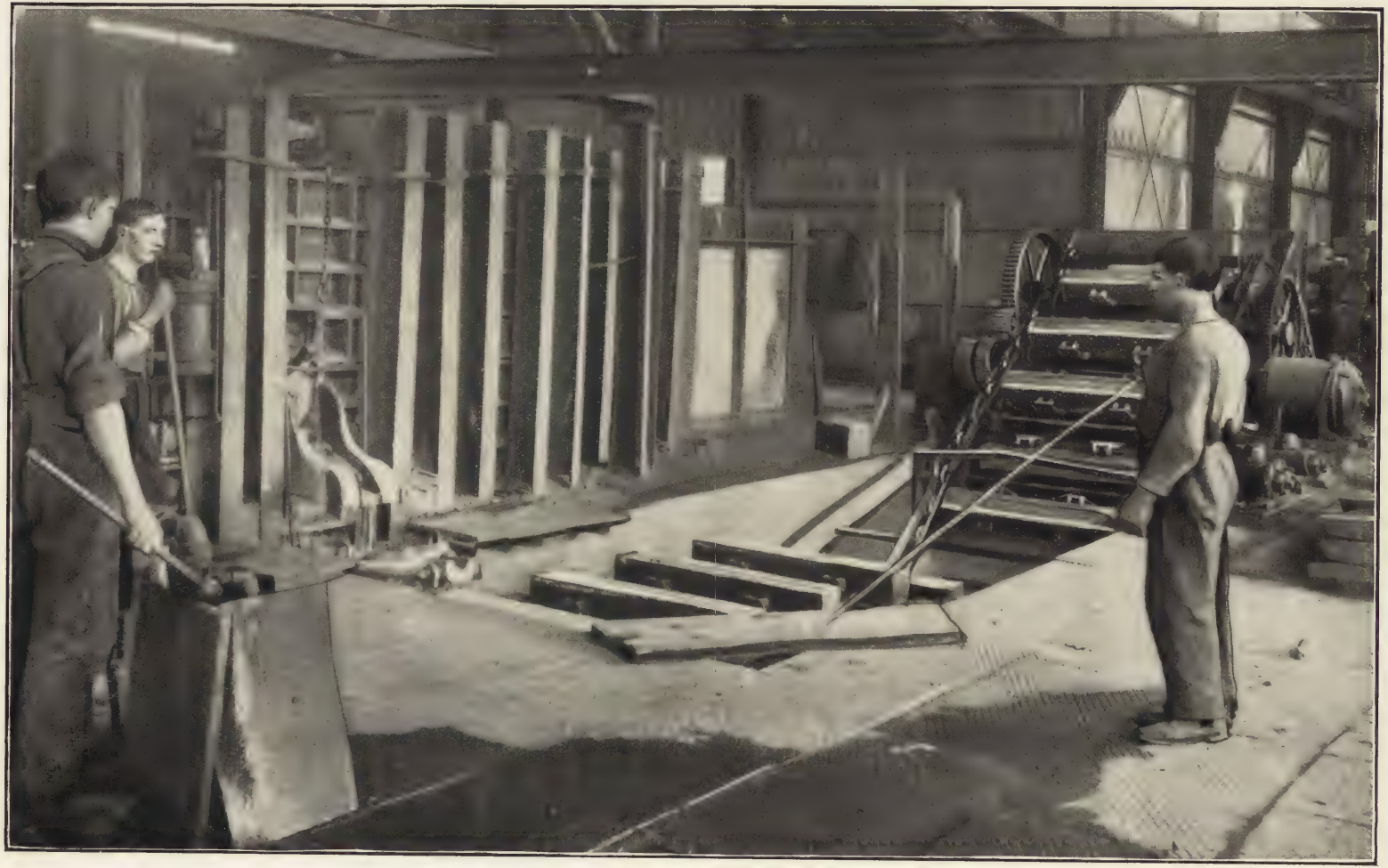


Fig. 12. Mechanical Casting Apparatus for casting wire-bars.

which flows from the spout while the conveyor is in motion. The stream from the furnace is governed by bits of wood thrust into the spout. The ladle, which is of iron, clay-lined, is raised and lowered by a hydraulic piston, controlled by the ladler. The copper in the ladle is protected from oxidizing influences by a layer of charcoal. The conveyor consists essentially of a series of copper moulds carried by an endless chain of link work. The system is moved by a 10-H.P. series railway motor, governed by the customary controller and geared to the driving head at one end of the chain. The moulds proper are mounted on four wheel carriages, the two pairs of wheels of which travel on pairs of rails of different gauge, so that a mould depends for its inclination from the horizontal upon the relative positions of the two sets of rails at the point of travel in question. The longitudinal axis of the mould is in line with the issuing stream of copper, but the line of passage of the mould, when the conveyor is in motion, is at right angles to this stream. The first condition permits the mould to be rapidly filled without splashing or causing any pinching from unequal heating, while the second condition prevents the "heeling up" of the still liquid metal at the end of the mould, which would result from the long waves produced, were the motion in the other direction. The moulds now filled are lowered horizontally, by means of the double rails, into water boshes where they remain long enough to cool without becoming totally chilled. As the entire mould with casting in place is submerged, unequal contraction and consequent trouble in delivering true castings is avoided. As the conveyor proceeds, the link work carries the mould and contained casting out of the water, and suspends them vertically for a moment to drain off the surplus water; it then moves over the driving head and dumps the finished wire-bar on guides which lead to a small truck. (In the photograph the steam may be seen rising from the water bosh and the mould which is draining is clearly shown. As the picture was a time exposure it was necessary to stop the flow of metal from the launder.) The mould under consideration now passes beneath on the return trip where it is daubed with bone-ash wash by an attendant and thoroughly dried by a current of hot air. The attendant in the pit marks on the inside of the mould the exact height to which it should be filled to give a bar of the standard dimensions.

The use of this casting device not only reduces the skilled labor to a furnace man and his helper but allows charges of 120,000 lb. to be poured in from four and a half to six hours, depending on the size of the bar made, frequently without a single bad casting.

The conveyors for the anode furnaces differ in detail but not in principle. The bosh is omitted as the appearance of the casting is no longer an object and the casting itself is so shaped that it cools sufficiently for rough handling without the use of water. The final cooling is usually accelerated by a thorough wetting down with a hose after the anodes are stacked up. The anode is prevented from sticking in the mould by a pin, which automatically forces it out from below, and is delivered on a pair of arms very much as a sheet of paper is delivered from a jobber's printing press. A pneumatic hoist now takes it with a pair of tongs and places it on a car specially designed for handling hot material. Each of these anode conveyors delivers without special effort a charge reaching

sometimes over 150,000 lb. in three hours. This figure is from actual working results and not a special estimate. In the cake-copper conveyor a reciprocating train is substituted for the endless chain and unloading cranes are provided at each end, the cakes being taken off at one end of the train while the moulds at the other end are being filled from the ladle situated midway between the cranes. The unloading device consists of two pneumatic hoists, one small and one large. The small one removes the frame in which the cake is cast and the large one then lifts the cake and carries it to a car placed conveniently on the industrial railroad.

The shot-copper well presents no particularly novel features. There is a launder direct from the furnace, and the issuing stream of metal is met by an air blast and a thin sheet of water which break it up into the desired form; the shot falls to the bottom of the well and is caught in an iron basket which when full is lifted out by a crane and the shot dumped into a suitable car. Over 8,000 lb. are handled at a time in the basket.

Silver Building.—In this building, which is of substantial brick construction, the slimes are separated into fine silver and gold, by the sulphuric acid process. The slimes are trucked in barrels through the tunnel from the basement of the tank house on to a hydraulic lift which carries them to the top of one end of the silver building. They are dumped on an 8-mesh screen, the coarse copper removed and the slimes washed through to a 60-mesh screen. The scrap copper from these screens is returned to the anode furnaces. The slimes are received in three settlers which in turn deliver them to six agitators. The water from the settlers is siphoned to a settling system outside of the building. In the agitators, sulphuric acid is added, compressed air introduced, steam in the heating coils turned on and the slimes and solution kept thoroughly agitated by paddles. After settling, the solution being run to the outside settling system and finally to the sulphate building to be worked into copper sulphate, the slimes now free from copper are sluiced into six drying tanks. Up to this point, the slimes have been carried from tank to tank by gravity. When thoroughly dried by steam coils they are sampled, weighed and taken to the furnace room adjoining. They now contain from 40 to 50% silver. The slimes are now charged in water-jacketed cupel furnaces, of which there are two, each accommodating a charge of from 2,000 to 3,000 lb. The resulting silver slabs are taken to parting kettles while the slag is melted with lead in a small reverberatory. The liquor from the parting kettle is carefully siphoned off and after settling the entrained gold, it is run into precipitating tanks, the cement silver from which is dried in special ovens, and melted into silver bars, 990 fine, each weighing about 1,000 oz. The doré bars from the parting kettles are re-parted in a third kettle and the resulting gold sediment carefully washed and melted in a small special furnace into gold bars, 985 to 990 fine, weighing about 500 oz. each. All of the furnaces lead into a long flue with a series of dust chambers terminating in an 80-ft. brick stack. The flue-dust is charged with the slimes into the cupel furnaces. The acid used is handled here, as elsewhere in the works, by compressed air, iron storage tanks being provided into which the contents of the acid tank cars are siphoned. Compressed air admitted to these tanks forces the acid through a piping system to wherever required.

Sulphate Building.—The building is of brick and is devoted entirely to making copper sulphate. The foul solution is pumped from the storage well in the tank-house cellar, by means of steam injectors, to this building where it is allowed to trickle through a series of oxidizing tanks, containing shot copper, with a corresponding series of settling tanks interposed. Thus the excess of free acid is neutralized and the sediment thrown down and separated. The solution is then boiled to 38 or 40°B. and run into crystallizing tanks. There are four oxidizing, five settling, three boiling and 30 crystallizing tanks. The crystallizing tanks are built over a cellar similar to that of the tank house which allows a thorough inspection for leaks. At the end of the building is a washing pan and a revolving conical screen for sizing. The shaft carrying the screen is hollow and affords a means of introducing jets of hot air, to dry the crystals while they are being screened. When the mother liquor, which is worked over several times becomes so foul that the crystals are poor, it is sent to a series of iron precipitating tanks outside the building and the copper content recovered in cement form.

Blast Furnace Building.—The blast furnace building, like the other furnace buildings, is built with a steel skeleton carrying corrugated iron sides and roof. The main floor is at the ground level and is covered with checkered cast-iron floor plates. The charging floor above is of heavy planking carried by steel floor beams and is covered with plate iron around the charging door. The equipment consists of a 30×66-in. Fraser & Chalmers water-jacket furnace with the usual dust chambers terminating in an iron stack, a 30-H.P. shunt motor, a No. 6A Green Rotary Blower, a 4×10-in. Blake crusher, a bucket elevator and a hydraulic lift. The material after crushing is carried by the bucket elevator to a series of bins on the charging floor, near which are the usual charging scales. The hydraulic lift outside the building allows material to be trucked directly when desired. The slag is dumped on lowlands near the building and the pigs of copper are loaded on cars of the industrial railroad to be taken to the anode furnaces. The flue-dust is charged back daily without briquetting. The furnace is used solely for the reduction of the oxide slag from the reverberatories. Oyster shells from the adjacent beds and burnt pyrites from chemical works in the vicinity afford advantageous sources of the lime and iron needed as flux.

Product.—The output of the works in refined copper is cast into wire-bars, ingots, cakes and slabs of various standard sizes as stated below. The quality of the copper is shown by the following average results, which were obtained from a number of lots recently tested and analyzed:

Physical Properties.			Composition.		
Percentage of Conductivity. Matthiessen's St'd. Annealed.	Tensile Strength. Hard drawn to No. 12 B. & S.	Twists in 6 inches. Hard drawn.	Cu. %	As. %	Sb. %
100·1	66,600	43	99·94	0·0020	0·0033

This checks closely the figure obtained (100%) for the average conductivity of all lots produced during a recent month—the determination of the conductivity of each lot being part of the daily work of the physical laboratory.

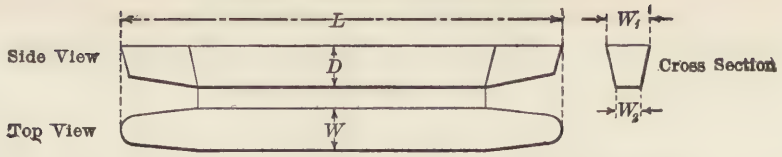


FIG. 13.—SHAPE OF WIRE BAR WITH POINTED ENDS.

WIRE-BARS, POINTED ENDS. (Fig. 13.)

Weight.	Dimensions in Inches.			
Pounds.	Length.	Upper Width, W_1.	Lower Width, W_2.	Depth, D.
77	34½	3⅜	3	3
100	35	3 7/16	3	3 7/16
135	38	3⅝	3¼	3⅝
155	39	3⅞	3⅜	3⅞
175	53	3 15/16	3 7/16	3½
200	49¼	3⅞	3½	3⅞
225	48	4⅛	3⅞	4
275	54	4⅜	3⅞	4⅜
300	51	4¾	4¼	4¾
420	84	4⅜	3¾	4⅜
575	88	4¾	4¼	4¾

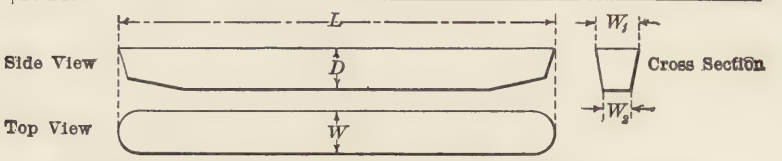


FIG. 14.—SHAPE OF WIRE BAR WITH ROUNDED ENDS.

WIRE-BARS, BLUNT ENDS. (Fig. 14.)

Weight.	Dimensions in Inches.			
Pounds.	Length.	Upper Width, W_1.	Lower Width, W_2.	Depth, D.
135	37½	3⅝	3⅛	3⅝
175	40½	3 13/16	3 7/16	3 13/16
212	40½	4 5/16	3 13/16	4 5/16
360	61½	4½	4	4½

SQUARE CAKES.

DIMENSIONS IN INCHES AND CORRESPONDING WEIGHTS IN POUNDS.

Thickness. Inches.	1½	2	2½	3	3½	4	5	6
Size. Inches.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
14x17	111	148	184	221	258	295		
18x18		291	251	301	352	402		
20x20		254	317	381	445	508	635	
24x24			466	536	625	714	893	
26x26			531	644	752	860	1,075	
28x28				729	851	972	1,215	1,458
32x32				977	1,139	1,301	1,628	1,953
37x37					1,485	1,608	2,122	2,546
38x38					1,607	1,836	2,295	2,755
40x40					1,780	2,035	2,544	3,052
45x45					2,254	2,576	3,200	3,864

SLABS.

DIMENSIONS IN INCHES AND CORRESPONDING WEIGHTS IN POUNDS.

Thickness. Inches.	1½	2	2½	3	3½	4	5
Size. Inches.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
30 x8	114	152	190	228	296	304	380
10 x25	118	156	197	237	277	316	395
12 x22	125	166	208	249	291	332	415
24½x8	93	124	155	186	217	248	310
48 x5½	126	168	210	252	294	336	420
48 x4½	102	136	170	204	238	272	340

The Manufacture of Blue Vitriol from Argentiferous Copper.

By Joel G. Clemmer.

The purpose of this paper is not to detail the progress made from the time it was first produced from mine waters to the present, but to describe more particularly a plant and process which answered all practical purposes for the economic production of copper sulphate crystals of best market value. In early days when the crystals were made from mine waters exclusively, the quality of the product was of little importance, as long as the impurities did not change the color to green. Perhaps this condition of the trade was due to the fact that the product, even though impure, then answered all practical purposes, but it is more probable that the lack of knowledge necessary for the production of a pure product had a greater influence on the subject.

At the present time the manufacturer, in order to command the best market prices, must produce a crystal of medium size, neither too large nor too small, with a uniform deep blue color; at the same time the crystal must contain a very small amount of free sulphuric acid, and a still smaller amount of iron and other impurities. For use in the electric battery a large sized crystal of a good grade is required so that a single one will suffice to replenish a cell. For making Paris green the crystals should be of one size, of uniform blue color, and should not contain more than a trace of iron and other impurities. For electrolytic purposes the size of the crystals is of no moment; the only requirement is that of purity, and at the present time it is the usual practice to obtain a pure product by frequent crystallizations. For agricultural purposes blue vitriol is used for making insecticides, Bordeaux mixture, etc., and for this purpose, the impurities may be large in amount as they have practically no effect on the products.

The manufacture of copper sulphate is described in ordinary books on Chemistry as follows: "Cupric sulphate, $CuSO_4$, commonly known as blue vitriol, is obtained by dissolving the oxide, carbonate, or hydrate, in sulphuric acid, or by roasting the sulphide. The salt crystallizes with five molecules of water, in triclinic prisms, which are soluble in three and one-half times their weight of cold water." This process is apparently simple and easy, yet when practiced on a commercial scale, is quite apt to prove too costly for profit. The usual oxidation of the copper in a furnace before dissolving it with sulphuric acid is unnecessary, and is dispensed with in the process described below.

The method of treating copper filings with oil of vitriol and then dissolving with water was not a commercial success, and has become obsolete. The Sorel* process, which consists of adding organic bodies, as oxalic acid, alkali oxalates, lactic acid, alkali lactates, tartaric, malic or citric acid, etc., to the sulphuric acid in order to facilitate the dissolving of copper, has yet to prove its commercial value.

Blue vitriol made from metallic copper is generally free from impurities, and commands the best market prices if the crystals are of fair size and of

* The Mineral Industry, Vol. VII., p. 228.

small acid content, but when made from roasted copper matte, or as a by-product from either the electrolytic copper refining process or the sulphuric acid process for separating gold and silver from copper, the product is impure and of low commercial value. From this statement should be excepted the product obtained by Ottokar Hofmann's excellent method, which is described in THE MINERAL INDUSTRY, Vol. VIII., p. 189, *et seq.*

The most economical method I have found for producing blue vitriol is from granulated (or shot) copper which contains silver and gold. No particular care is required to free the copper from impurities other than iron, and the granulation of the copper is quickly and cheaply accomplished by providing a walled and cemented well at the tapping side of the furnace. The well must have a continuous flow of water during the time of granulation. The dimensions of the well will depend upon the capacity of the furnace or the charge of copper used, and must be large enough to keep the granulated copper submerged in the water while tapping. An iron bucket handled by an overhead stationary or traveling crane, fits loosely in the well, and receives the granules. An iron spout from the tap hole of the furnace projects over the side of the well, and during the tapping, a pole of green wood is held under the stream of molten copper, which granulates it sufficiently for the purpose. While the copper is flowing from the furnace, care must be taken to keep the stream thin, and to have an intermittent flow, otherwise explosions will take place.

The cheapest grades of copper mattes from lead works are the most economical for this purpose. These contain silver and gold, and furnish an additional source of profit, as the precious metals are recovered as a by-product in the form of rich slimes, assaying from 7,000 to 10,000 oz. silver per ton. The following analyses are of copper mattes of this character:

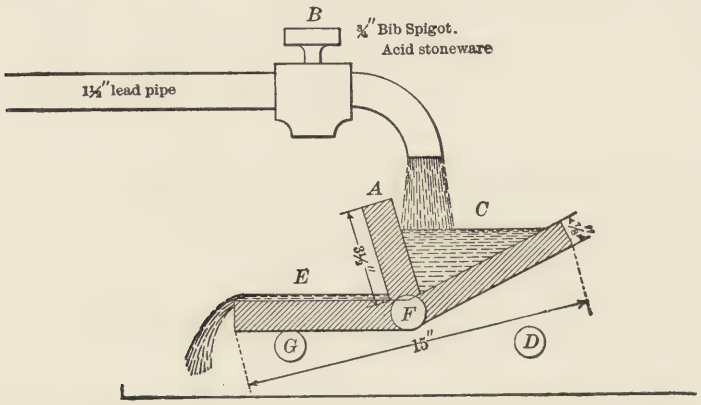
Source.	Cu.	Ag.	Fe.	As.	Sb.	Pb.	Zn.	Si.	S.
	%	%	%	%	%	%	%	%	%
Pennsylvania Lead Co..... ...	43·40	0·34	14·36	1·04	0·63	13·04	1·39	0·27	24·96
St. Louis Smelting & Refining Co...	42·01	0·47	14·00	0·39	0·07	16·30	2·49	0·20	23·85
Kansas City Smelting & Refining Co	40·10	0·38	15·44	0·56		17·37	1·89	0·30	23·40

The dissolving of the granulated copper with sulphuric acid without a previous furnace oxidation, is accomplished by placing the granules in short towers (called "oxidizers" and "dissolvers"), 3 ft. long, 3 ft. 3 in. wide and 6 ft. 6 in. deep (inside dimensions), and lined with lead (15 lb. per sq. ft.). Each tower has an opening 1 ft. square at the bottom and center of the front, which serves as an outlet for the liquors and an inlet for air. The towers are provided with false bottoms to support the shot copper, made up of several 0·75-in. iron pipes, each covered with a heavy lead pipe with the overlapping ends closed. These pipes are placed side by side 1 ft. from the bottom, upon chemical bricks set in the towers to the right and left of the bottom openings. The air space under the false bottom serves to collect the silver slimes.

The proper condition of the sulphuric acid for the most rapid solution of the copper is 10° B. strength at 190° F. temperature. The acid is spread over the shot copper in each tower through a flanged sheet of lead perforated with two

quarter-inch holes for each sq. in. of surface. These sheets are placed upon the top of the shot copper and the spreading of the acid is accomplished by an oscillating trough. The trough, 34 in. long, is divided longitudinally by a partition *A*, and the lead pipe and cock *B* convey the acid from a reservoir into the top compartment *C*. When this is full, the trough turns on its axis *F* (its center of gravity being changed), until it is stopped by the rod *D*, and the acid flows out. As a result of this turning, the second compartment, *E*, is elevated, and when filled in its turn is tilted back to its first position, where it is stopped by the rod *G*. In this manner the continuous oscillation of the trough distributes the flow of acid, first to one side and then to the other.* The troughs are made of 0·875 or 1 in. wood, preferably yellow pine. The ends, bottom and partition are grooved and pinned together, the axis being an extended part 3 in. long, from each end of the bottom. When put together it is soaked in thin turpentine asphaltum to increase its durability. The trough may consist of a lead covered iron frame, but this is more expensive to construct.

The strength of copper sulphate liquor issuing from the towers will naturally



OSCILLATING TROUGH FOR THE DISTRIBUTION OF ACID.

depend upon the speed and heat of the acid delivered into them, and must be regulated according to requirements. The towers, or dissolvers, are daily replenished with copper, added by a shovel, after removing the perforated lead sheets. During this charging it is not necessary to shut off the flow of acid. It is a good plan to shut off the acid supply to one tower at a time, at intervals of about a month, and wash out the towers with water under pressure, removing the wash water and residues to the slimes tank by a movable spout. This operation separates the slimes adhering to the shot copper, and allows their quick conversion into a marketable condition, and, in addition, it aids the acid attack on the copper.

The slimes which collect in the free space at the bottom of the tower may be removed at any time without washing out with water or shutting off the acid.

* Lunge's "*Sulphuric Acid and Alkali*," Vol. I., 1879, p. 311.

For a small plant producing 5,000 lb. copper sulphate per diem, six dissolvers, as above described, will be ample; with these should be connected 10 crystallizing tanks, 10×10×3 ft. deep (inside dimensions). It is preferable to taper the crystallizing tanks each side 1 in. from top to bottom for the better adherence of the crystals. This construction modifies the dimensions to 10× 10 ft. at the top and 9 ft. 10 in.×9 ft. 10 in. at the bottom. The crystals form on lead straps, hung in the tanks from wooden cross-pieces, and completely surround them, and cannot fall off. When the sides of the tanks are perpendicular, the lead invariably "buckles" from the hot liquor and the weight of the attached crystals. This objection is overcome with the inclined sides, as each crystal naturally supports the upper ones next adjacent to it, and as a result, the entire mass of crystals on the sides is of greater strength and durability. Each tank is emptied of the mother liquor at the close of the crystallizing process by means of a plug and plug seat, the latter is burnt to a lead pipe, which leads to a trough or gutter, for the conveyance of the mother liquors to a common center, generally a tank set below the level. This method requires much less time than the customary siphoning operation, which has the additional disadvantage of leaving a layer of liquor at least 1 in. high that must be dipped or shoveled off.

An alloy of 90% lead and 10% antimony gives excellent results when used for making the seats and plugs.

The plant is generally arranged in terraces so that the transportation of the liquors will be accomplished by gravity. The acid tanks are at the highest level with the towers, directly in front on the second level; the combined receiving and settling tanks are placed on the third, and the crystallizing tanks on the fourth and lowest level. The gravity floor is completed at the mother liquor tank, which is sunk in the earth below the last level. The crystallizing tanks are arranged in double rows, with a 2-ft. space between, and are constructed on the lead covered floor placed directly on the earth surface, which is inclined toward the sunken tank or "sump," and serves as a common receiver for the entire system. The space between the double rows slopes to a gutter for the conveyance of the mother liquor and any leakage to the sump. The wash floors for the crystals are in front of the crystallizing tanks, and slope toward the sump for the collection of the wash waters. A continuous drying apparatus is placed at the other side of the floor, opposite the tanks.

This arrangement furnishes a gravity flow of the liquors from the acid tanks at the topmost level, through the towers, receivers and settlers, crystallizers and finally to the sump. The acid, of course, must first be raised to the acid tanks, generally done by a steam injector.

When the plant is not terraced, but constructed on one level, the cost of handling the liquors by steam injectors from tank to tank is considerable.

The weights of the sheet lead for lining the tanks, expressed in pounds per square foot of surface, gave the best results when selected as follows: Acid reservoirs, 10 lb.; towers, 15 lb.; receiving and settling tanks, 8 lb.; crystallizing tank, bottom, 10 lb.; sides, 8 lb.; floor under tanks, 3 lb.; gutters, 6 lb.; wash floors, 10 lb.; sides, 8 lb.; and sump tank, 6 lb.

The proper strength of the sulphuric acid to start the process of dissolving the shot copper is 10° B. By the passage of this acid several times through the dissolvers, or towers, in the manner described, it is concentrated to crystallizing strength, which, for best results, is 34 to 35° B. at 60° F. The crystallizing liquor should contain not more than 1% of free sulphuric acid, as this small quantity does not affect the appearance or quality of the crystal, nor does it in any way injure the sale; in fact, it adds weight, which is not copper, to the crystal, and costs less than copper—an item not to be overlooked.

Should the solution or liquor from silver-bearing copper be made neutral, in the dissolving towers, all the impurities will be precipitated in the silver slimes. This neutral solution, however, dissolves silver, and loss will ensue unless sodium chloride, or preferably hydrochloric acid, is added, to precipitate the dissolved silver as chloride, and to collect it in the slimes. Best results are therefore obtained by leaving 1% free acid in the liquor ready for crystallization. At the completion of the crystallizing process, during which the liquor has had ample time to segregate, those sulphates of lesser specific gravity than copper sulphate will have risen to the top, and may be drawn off from the copper mother liquor; their small amount of copper is regained by pouring the solution over scrap iron, which precipitates it. In this manner the mother liquors, after dilution with water, can be used, in place of fresh acid, for the dissolving towers; and in actual practice there is very little danger of the liquors becoming too foul for crystallizing purposes. Electrolytic refiners who boil down their electrolytes for crystal, and run the remaining solution over scrap iron, may find it profitable to adopt the above practice; and in the electrolytic process itself this point may be of advantage, as it naturally follows that the electrolyte will segregate in the depositing tanks if its circulation be stopped for a few hours. The greater portion of the arsenic and impurities in solution may then be drawn off and removed to the bluestone department, thus avoiding excessive recrystallizing of the solutions. This method has been successfully used for some years with anodes made almost exclusively from foul, leady mattes.

With a standard strength of the liquor, the size of the crystal will depend upon the number of straps suspended in the tanks. In other words, the greater the surface for the blue vitriol to crystallize upon, the smaller the size of the crystal, and vice versa; slow cooling of the liquor favors the prevention of small crystals. In a few blue vitriol plants of ancient construction the crystallizing tanks were 8×6×6 ft. deep to prevent the liquor from cooling too quickly. Tanks 10×10×2 ft. deep also have been used; the best size, however, is 10×10×3 ft. deep. In use, the tanks should be covered immediately after filling with loose boards to prevent the "salting out" of the blue vitriol with the consequent formation of too great a quantity of "fines," and, of course, a lessened production of crystals, which, under these conditions, are small in size.

The crystals are dried quickly and cheaply by passing them through a revolving brass screen (0·25-in. mesh) enclosed in a small wooden chamber, with sides removable in sections. The chamber is heated by live or exhaust steam,

and has a small exhaust fan to remove the moist air. The crystals are fed by copper conveyors into the screen, the exit end of which is sufficiently elevated to feed the dry crystals direct into a barrel. The "fines" which pass through the screen are carried by conveyors from below the screen to any part of the plant desired. The usual method of reworking the "fines" consists in placing them in a perforated lead basket suspended in heated and diluted mother liquors, and recrystallizing them from the solution thus formed.

The cost of manufacturing copper sulphate depends largely upon the capacity of the plant. One of 25-tons' daily output will naturally make a cheaper product per pound than a plant of one-tenth the capacity. Profit is sometimes made by producing the copper instead of purchasing it on the market, and a sulphuric acid manufacturer has an advantage of a supply of acid at first cost, and an outlet for his "weak distillates," which can be used for copper sulphate production, thus saving him the expense of reconcentrating them.

It is a difficult matter to give the cost of the manufacture of copper sulphate under all circumstances. A favorable combination for a diminished cost of production would be the combination of the process, as outlined above, with the manufacture of sulphuric acid and metallic copper at a plant located near New York City; this location affording a saving in freight charges. Under these conditions it is estimated that the cost of making 5,000 lb. copper sulphate (ready for shipment) per diem, assuming that the manufacturer also produces copper and sulphuric acid and that the location of plant is in the vicinity of New York City, would be about as follows: Copper and sulphuric acid, $152·63; foremen and labor, $11·50; packages, $4·80; fuel, $9·00; repairs, insurance, depreciation, etc., $6·00; total, $183·93, or about 3·73c. per lb. In the opinion of the writer this estimate may be considered high.

Recent Progress in the Henderson Process for Extracting Copper from Pyrites Cinders.*

By Joel G. Clemmer.

There has been no change in the principles of the original Henderson process for the extraction of copper, silver and gold from pyrites cinders by first chloridizing and subsequently precipitating these metals on iron. Special points of progress, however, have been made in the construction of the furnaces and tanks and in the method of handling material.

Henderson's proposition to volatilize the entire amount of copper contained in the cinders, collecting and condensing the volatilized metallic salts in condensing towers (thereby saving the cost of leaching) has not been a commercial success, although theoretically the process is correct. In the ordinary chloridizing process there are always some metallic salts volatilized during the roast, and condensing towers are therefore necessary to collect these metals as well as to furnish acid for the leaching operations.

To chloridize the copper, silver and gold successfully requires a proper grinding of the pyrites cinders and a thorough admixture with salt. If the entire amount of cinder is ground or pulverized to one size, two difficulties arise. If too fine, a slimy, adhesive mass will be formed in the tanks and the leaching process seriously hindered, while if too coarse, trouble will arise in chloridizing the copper content in the furnace and the time of leaching will be unnecessarily prolonged. The best general results are obtained by having one-third of the ground product about 0·125-in. mesh in size and the remaining two-thirds in a state of very fine division, delivering the entire product to the furnace intimately mixed with the required amount of salt.

Crushers.—In modern works, Cornish rolls and screens have been replaced by various grinding mills although some of them are not adapted to the treatment of pyrites cinders owing to the tendency of the material to become sticky when moisture is present, which results in clogging the mill. The crusher of the coffee mill type is among the poorest for this purpose, although it gives excellent results in grinding soda crystals, bauxite, coal, etc. The best mill for grinding cinders now in use at modern works is the Carlin mill, shown in Figs. 1 and 2. A mill of this size has a daily capacity of grinding and mixing 50 tons of cinders and salt, an amount that could be increased to 100 tons if the material were dry.

The salt, in amount dependent upon the copper content of the cinder, is usually fed to the mill with the cinder, adding a shovelful of salt to about six of cinders. In a similar way pyrites is added when the sulphur content of the cinders is too low. The cinders, salt and green ore are mixed, ground and sieved and then carried by bucket conveyors from the grinding pan of the mill to overhead storage bins.

Fig. 3 shows the patent steel sifter plate of the Carlin mill for grinding and mixing pyrite cinders and salt; the cast metal sifter, as shown in the figure, gives good results for the reason that the wear of the sifter bars is not uniform and the

* The Henderson process has been fully described by Mr. Clemmer in his article entitled "The Extraction of Copper from Burnt Pyrites by the Henderson Process," The Mineral Industry, Vol. VIII., p. 197.—Editor of The Mineral Industry.

sections are removed one by one. In this way the old sections allow the passage of coarse material, while those newly made allow only the fine material to pass through. As the sifter plate comes from the foundry the slit openings are less than 0·0625 in. in width. It is to be noticed that these openings are parallel with the direction of movement of the scraper in the grinding pan; in this position the sticky mixture of pyrites cinders and salt passes through more readily than if

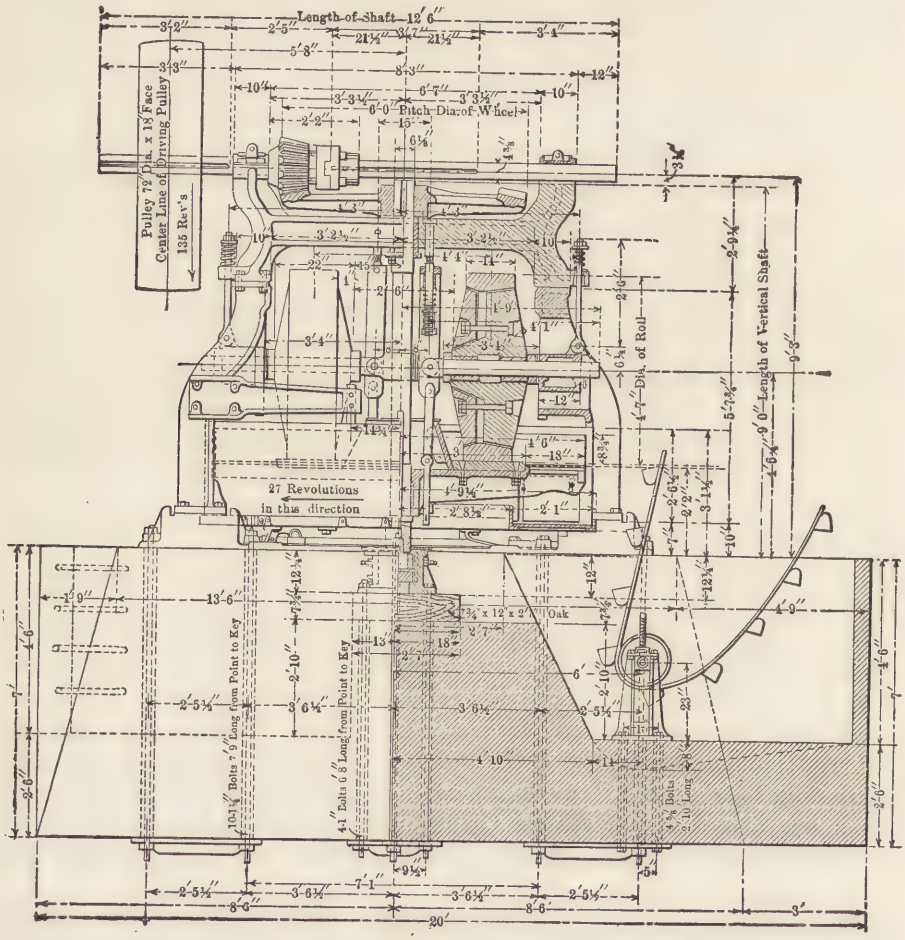


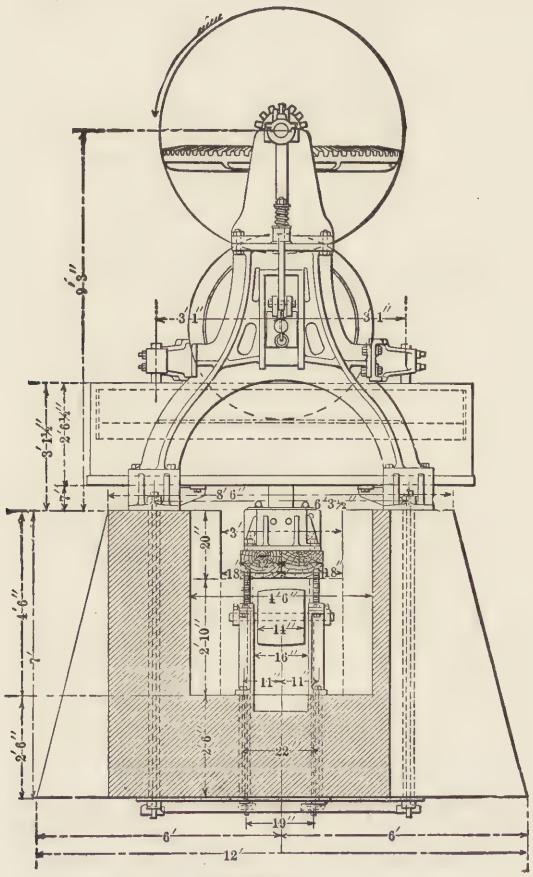
FIG. 1.—THE CARLIN MILL.

the openings were at right angles, as in the usual construction of the plate for the treatment of other material.

A power feeding device for the mill has been recently installed at a modern American works and has increased the mill capacity and diminished the amount of labor required.

Roasting Furnaces.—Muffle furnaces have almost entirely superseded the old reverberatory furnaces for the chloridizing roast. Contrasting the action of the

two types of furnace, the muffle possesses the advantage of requiring but one-half of the condensing capacity, as only the gases resulting from the chloridization pass through the towers while in the reverberatory the gases of combustion as well must pass through. Apart from this decided advantage of the muffle furnace, better results are obtained, as both the gases from the reaction and those from the combustion are under separate control. The construction of the modern muffle furnace is well illustrated in detail in Fig. 5. The arch at the fire-box



Cross Section.

FIG. 2.—THE CARLIN MILL.

end is made double to prevent the cinders from becoming overheated at that end, and the fire-flue is placed beneath the furnace rather than in the end passageway, which is constantly traversed by the workmen. This arrangement adds greatly to their comfort under foot. A bridge wall is constructed beneath the bed or hearth of the muffle and guides the heat directly beneath it to the entrance of the underground flue at the fire-box end where the fire-flue damper for controlling the draft is located. The furnace has doors on both sides of the fire-box and muffle. The furnace shown in the illustration was designed for the treatment of

cinders containing less than 2% Cu, with a normal amount of sulphur, the charge being of usual weights. For cinders of greater copper content or treated in larger charge amounts the furnace dimensions would necessarily be increased. With poor draft either in condenser or in stack, a larger cross section of gas and fire flues would also be required.

It is the usual custom to run a tramway directly on top of the reverberatory furnace, charging it by dumping the material through openings in the roof that are covered, except during the charging of the furnace, by doors generally of sheet iron. This method of charging may also be used with a muffle furnace, but it is far more convenient to have charging hoppers and pipes that are filled from an overhead floor, as shown in the illustration. This is a decided advantage, as the charging operation is then entirely independent of the working and the chargemen therefore are not required to wait until the furnacemen are ready to have the charge made. The hoppers hold sufficient material for an entire charge.

The gases from the muffle are carried off through cast-iron pipes, as indicated in the illustration (Fig. 4). These pipes are easily replaced as they have no bells and are joined by cast-iron bands which are halved, bolted and packed with

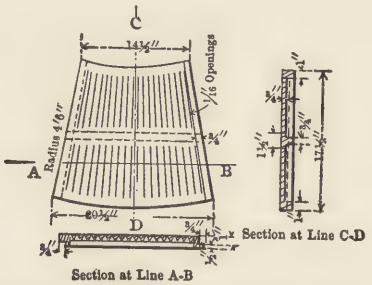


FIG. 3.—SIFTER PLATE FOR CARLIN MILL WHEN OPERATING IN PYRITES CINDERS.

asbestos previously soaked in tar, or with a putty of fire clay and soft tar. Each section of pipe is provided with a manhole for cleaning. This method of conducting muffle gases is much better than the old gas flues which were constructed of a number of cast-iron plates 10×12×1 in. thick, placed on old rails, for the bottom, the brick side walls being supported directly on these plates and the top formed of a second series of cast-iron plates placed directly on the brick side walls. A slurry of fire clay was used to fill the numerous cracks between the bricks and the plates.

The use of a mechanical roasting furnace in place of the hand-operated muffle or reverberatory furnace would naturally reduce the labor cost to a considerable degree and would afford, as well, a large saving in the quantity of salt required due to the more intimate stirring of the material during the roasting operation. Many costly attempts have been made in this direction but as yet without success, although in one plant of modern construction a Pearce double-turret roasting furnace has been installed. Its working, however, has not yet been satisfactory as difficulty has arisen from the caking of the material in the furnace.

Conveyors.—The use of a mechanical conveyor to carry the chloridized material from the furnace to the leaching tanks is of questionable advantage as the

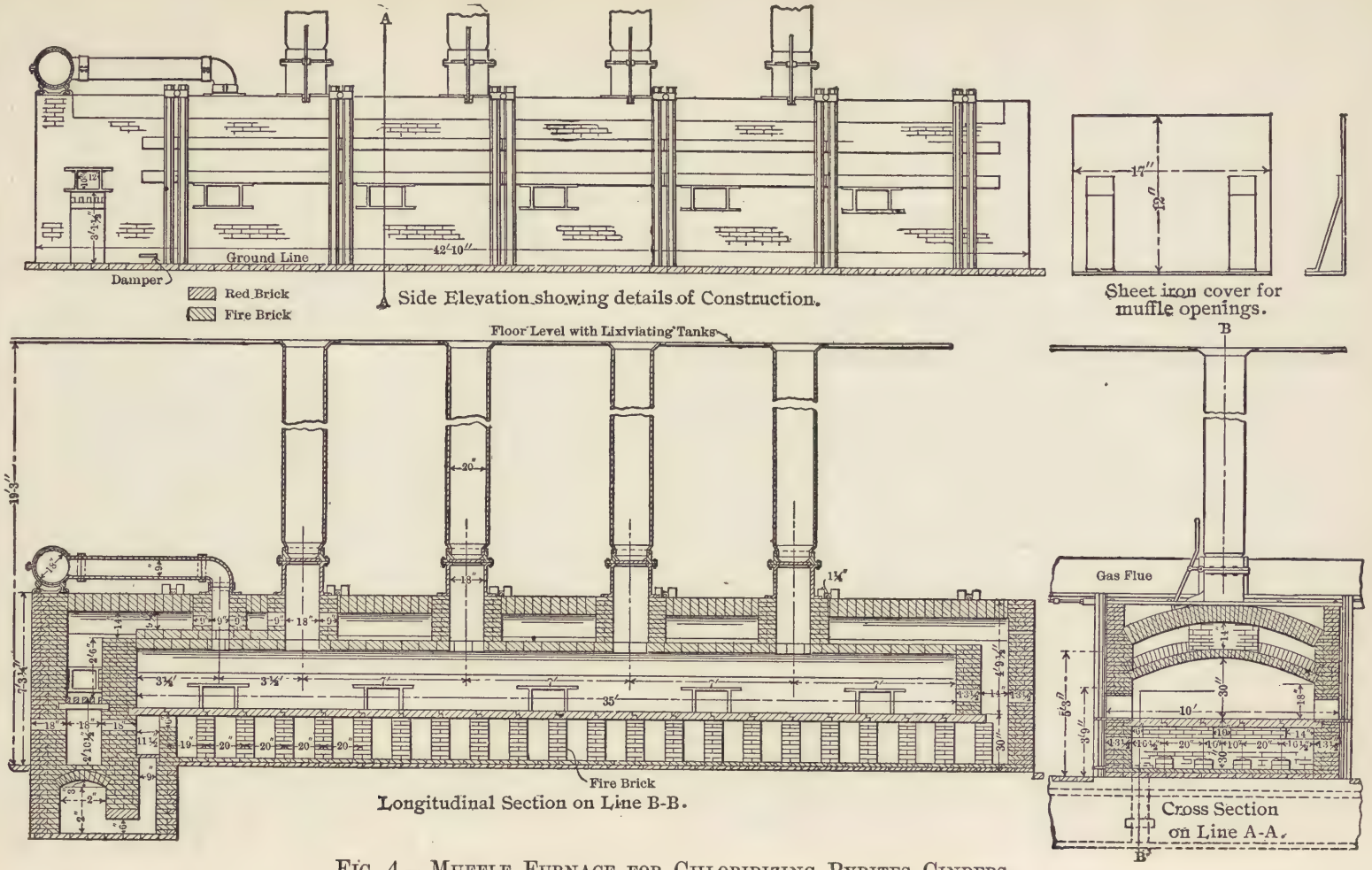


FIG. 4.—MUFFLE FURNACE FOR CHLORIDIZING PYRITES CINDERS.

material must be passed in a thin stream over the necessarily long distance which causes it to become cold or nearly so, and the subsequent leaching operation is thereby unduly prolonged. While the old method of removing the material from furnace to tanks in side-dumping tramcars may be more expensive in labor it possesses the advantages of quick work and of delivering the material to the tanks while it is still heated, a condition that hastens the time of leaching. For convenience the cars may be loaded directly from the furnace by having the track sunk below the ground level.

Tanks.—It is the usual practice to locate the leaching tanks at a level which will permit the residuum—purple ore or blue billy—to be loaded directly on gondola cars for shipment, and as heavy loads of furnace material are conveyed to the tanks for leaching, a quick acting elevator is required. Steam is gen-

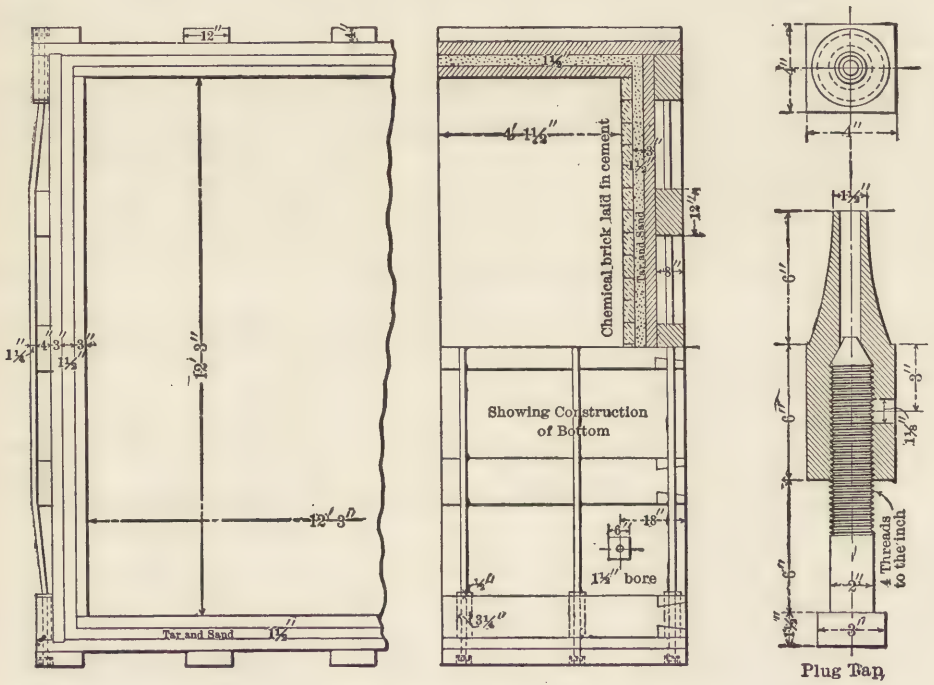


FIG. 5.—DETAILS OF TANK CONSTRUCTION.

erally used for the pressure, the combined inlet and outlet exhaust being controlled by a three-way valve and the speed adjusted by a set-cock in the pipe entering the top of the cylinder.

The details of tank construction in modern practice are fully given in Fig. 5. The 2×2 in. beveled wooden slats have been replaced by hard-burned red brick laid flat side by side, which affords a more durable, less troublesome and, all things considered, a cheaper construction. The former rubber pipe for discharging the tank has been superseded by the more convenient wooden spigot construction details of which are fully treated in the illustration.

Condensing Tower.—There has been no change in the method of condensing

the acid gases from the furnaces although in one plant I have recently noticed an auxiliary wooden condenser that was attached to each brick condensing tower for the purpose of catching any acid gases that escaped from it.

This extra construction seems unnecessary unless the main condenser is of insufficient capacity.

Purple Ore or Blue Billy.—The makers of pig iron have recently objected to the receipt of too much of the leaching tank residue on account of the large amount of fine material it contains. To overcome this objection the fines are now formed into briquettes by an ordinary automatic brick machine and burned in a down-draft kiln.* The demand for these briquettes of a sulphur content less than 0·25% is quite large. Some pig iron manufacturers require the elimination of all the sulphur from the material and to meet this, it is necessary to burn the briquettes in the kiln at a very high temperature for five or six days. In fact the briquettes are virtually fused.

The Claudet Process for Precipitating the Silver.—For the reasons given in my previous paper on the Henderson process,† the expensive Claudet modification for precipitating the silver from the copper liquors has been entirely abandoned in the United States.

* Refer to the article on "Clay," by H. Ries, elsewhere in this volume.

† THE MINERAL INDUSTRY, Vol. VIII., p. 197.

COPPERAS.

COPPERAS is produced in the United States especially by the manufacturers of steel wire and rods and sheet steel, some of whom recover by crystallization the vitriol from their pickling liquors. A portion of the product is calcined either with or without the admixture of lime, and marketed in the form of Venetian red or Indian red, while copperas as such finds application in the manufacture of inks and Prussian blue, polishing plate glass, coloring paper, dyeing cotton and woollen fabrics and in various branches of the chemical trade. It is also used to some extent as a fertilizer and deodorizer and in the place of bog iron ore as a gas purifier.

The total production of copperas in the United States in 1900 was 12,374 short tons, valued at $96,517, against 13,770 short tons, valued at $108,508 in the preceding year. These figures do not include the amounts calcined for pigment, the output of the latter product being reported under the caption "Ocher and Oxide of Iron," elsewhere in this volume. The largest producer of copperas in 1900 was the American Steel & Wire Co., which operated plants in connection with the manufacture of wire and rods at Worcester, Mass., Cleveland, Ohio, and DeKalb and Waukegan, Ill. Among the other producers were the Pennsylvania Salt Manufacturing Co., Natrona, Pa., C. K. Williams & Co., Allentown, Pa., S. P. Wetherill & Co., Philadelphia, Pa., Atlantic Dynamite Co., Dover, N. J., and Joseph Wharton, Camden, N. J. New plants were started by the National Wire Corporation, New Haven, Conn., the Forest City Mfg. Co., Elwood, Ind., and Charles Lennig & Co., Philadelphia, Pa. Small shipments of copperas are made from time to time from Steubenville, Ohio, where it is formed naturally by the oxidation of a body of pyrites.

The price of copperas at New York during the greater part of 1900 was about 72·5c. per 100 lb. In November the appearance of the new manufacturers in the field caused a sharp decline and for the remainder of the year the prices ruled at 40 to 50c. These quotations are for carload lots, an additional 5c. per 100 lb. being asked for smaller quantities. At $8 per ton, which includes cooperage and transportation to New York, it is stated on good authority that there is little or no profit in the manufacture. The present capacity of the various plants engaged in the industry is much in excess of the demand, and unless some new outlet for the product should be found the field can offer no inducements to new ventures.

FELDSPAR.

THERE has been a steady increase in the production of feldspar for the past three years, the output in 1900 amounting to 29,447 long tons, valued at $136,773, against 26,968 tons ($137,886) in 1899. The chief sources of supply were, as heretofore, Brandywine Summit, Embreeville and Chadds Ford, Pa., Bedford, N. Y., Branchville and South Glastonbury, Conn., Huntington, Mass., and Georgetown and Topsham, Me. The less important mines in Delaware, Virginia and South Carolina yielded a small amount.

For a detailed account of the occurrence, mining and uses, reference may be made to the article by T. C. Hopkins in THE MINERAL INDUSTRY, Vol. VII.

PRODUCTION OF FELDSPAR IN THE UNITED STATES.

State.	1898.		1899.		1900.	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
Connecticut	6,696	$37,944	11,104	$61,311	13,166	$63,872
Maine and Pennsylvania	12,954	58,953	14,644	71,755	14,481	65,901
Massachusetts	150	525	160	560	800	2,800
New York	1,550	9,725	1,060	4,240	1,000	4,200
Totals	21,350	$107,147	26,968	$137,866	29,447	$136,773

New mines were opened in 1900 near Ticonderoga, N. Y., on the property of W. S. Stewart. The deposit is in the form of a dike from 10 to 40 ft. wide which contains about 75% feldspar, 20% quartz and 5% mica. A mining plant has been erected by Golding & Sons Co., of Trenton, N. J., and shipments will begin in 1901. A mining lease of a feldspar property in Section 22, Town 47 North, Range 29 West, Upper Michigan, was taken out for a term of 30 years. Feldspar occurs at several points in this State, but as a rule the product is impure and unsuited to the requirements of the pottery trade.

The price of feldspar ranges from $3 to $6 per long ton at the mine, according to quality, while the ground product of satisfactory grade brings about $7 per ton at Trenton, N. J. For pottery uses it must be free from iron oxide, mica and quartz.

FLUORSPAR.

ALTHOUGH there was considerable activity in fluorspar mining during 1900, the production did not reach the figures of the preceding year. The statistics as reported by the several companies engaged in the industry are for 1900, 21,656 short tons, valued at $113,430, against 24,030 short tons ($152,655) in 1899. The output for both years was largely in excess of the shipments, which can be explained only by the accumulation of stocks at the mines. The largest producers continued to be the Kentucky Fluorspar Co., the Rosiclare Lead and Fluorspar Mines and the Fluor Spar Co., while the Eagle Fluorspar Co. mined a small amount. New companies, including the Western Tube Co., of Kewanee, Ill., and the Consolidated Oil and Gas Co., of Canton, Ohio, did some development work on their properties. Prices in 1900 were subject to frequent variations, but they ruled about as follows: Gravel spar, $5; lump spar, $5·50; ground spar, $10. These quotations are per short ton f. o. b. at mines. The average value of the fluorspar production was $5·24 per short ton, against $6·35 in 1899.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton
1889....	9,500	$45,835	$4·82	1893.....	9,700	$63,050	$6·50	1897.....	4,379	$36,264	$7·65
1890....	8,250	55,328	6·70	1894.....	6,400	38,400	6·00	1898.....	12,145	86,985	7·16
1891....	6,320	38,000	6·00	1895.....	4,000	24,000	6·00	1899.....	24,030	152,655	6·35
1892....	9,000	54,000	6·00	1896	6,000	48,000	8·00	1900.....	21,656	113,430	5·24

PRODUCTION OF FLUORSPAR IN THE PRINCIPAL COUNTRIES. (IN METRIC TONS.)

Year.	France.	Germany.					Spain.	United Kingdom	United States.	Total.
		Anhalt.	Bavaria.	Prussia.	Saxony.	Schwarzburg.				
1896.....	1,940	5,600	5,218	8,672	805	1,218	3	400	5,443	29,629
1897.....	2,722	7,000	4,904	10,095	592	641	2	303	4,299	34,678
1898.....	3,077	6,415	4,440	11,863	775	294	5	507	11,018	38,394
1899.....	5,140	5,815	3,631	12,932	1,355	573	310	796	21,800	52,352

From the official reports of the respective countries except the United States, for which the totals are based on direct returns of the producers, and for Anhalt, Saxe-Weimar and Schwarzburg-Sonderhausen, which are due to the courtesy of Herr von Scheel, director des Kaiserlichen Statistischen Amts.

In the American market, fluorspar is divided into six grades: American lump No. 1; American lump No. 2; gravel; crushed; ground fine; ground extra fine. The foreign product appears in two grades only: Lump and fine.

The Fluorspar Mines of Western Kentucky and Southern Illinois.

By W. E. Burk

The deposits of fluorspar with their associated zinc and lead ores are limited to a few counties in western Kentucky and southern Illinois, chief among which are Crittenden and Livingston counties, Ky., and Hardin County, Ill. Small amounts of low-grade fluorspar are produced in Caldwell County, Ky., and it occurs also in Polk County, Ill.

The industry in the Illinois part of the district, which has Rosiclare as a shipping point, is quite old, and for years furnished all the commercial demands for the mineral. At present only one company, the Rosiclare Lead and Fluorspar Mines, is operating here, and the shipments average about 5,000 tons per annum. There are three known veins near Rosiclare which carry fluorspar.

Since attention was attracted to the Kentucky part of the district, this State has rapidly gained in importance and now produces the greater part of the total supply. The deposits are so distributed and so extensive that they can be worked in a large way for years to come. In 1900 the shipments amounted to about 9,000 tons, all of which was handled by the Illinois Central Railroad from Marion, Crayneville, Mexico, Fredonia and Crider stations. The shipments were consigned to various points in the States of Pennsylvania, New York, Ohio, Indiana, Illinois, West Virginia, Missouri, Alabama, Iowa and Connecticut, and also to Ontario, Canada. The most important mines in this section are those operated by the Kentucky Fluorspar Co. in Crittenden County, which alone shipped over 6,000 tons in 1900, about one-third of this being in ground form. This company has a crushing and pulverizing plant at Marion, Ky., where by using buhr mills a high degree of comminution is obtained. The pulverized product finds a market in the manufacture of hydrofluoric acid, opalescent glass and enameled ware. A much higher price is obtained for the ground fluorspar than for the lump grades used in steel manufacture.

Geology of the District.—The occurrence of fluorspar or fluorite is distributed quite generously over the district in numerous small vertical veins and the association of zinc and lead ores is noted in small quantities. In some of the prominent veins, however, both zinc and lead as sulphides and carbonates appear in high percentages with a calc-spar and fluorite gangue. The formation is sub-Carboniferous, the highest hills at top still retaining fragments of shale strata from pre-existing coal-measures. To the north and northeast, where erosion has been less marked, are valuable deposits of bituminous coal which are now being worked, while as one travels to the west and south the erosion has been greater and geological conditions change very rapidly limiting a zone peculiar to itself and at one time offering the unusual conditions conducive to such a deposition as is here exhibited, which is, I believe, the only known one of such extent in the world. For the most part the rock strata generally approximate their original position, although at times, the district is crossed by several faults and along these the rocks are tilted, sloping away in such manner as to leave no doubt of a local uplift, determining the fractures.

Differential stress has produced a slip of one side past the other to the extent

in one case, at the Columbia mines in Crittenden County, of probably several hundred feet. In central Crittenden County, along the Columbia vein, certain hills, locally called "Hog Backs," seem to locate the center of uplift for the immediate district. No igneous material is in evidence, however, and the importance of the uplift so far as deposition of mineral is concerned, is limited to the formation of the numerous fissures, some of them faults, the actual deposition of mineral being secondary. The origin of these deposits lie in fumarolic action, as is evidenced by the abundance and position of the fluorite, aided by general segregation of the rock masses from perhaps a considerable drainage basin. Springs of water heavily charged with hydrogen sulphide are found along the principal lead and zinc sulphide deposit in the Columbia vein, one of which supplies a local health resort, the Crittenden Springs Hotel.

These fissures can be traced for miles. They are barren of mineral contents in many spots while at others secondary concentration has resulted in the pay lodes—bonanzas—being formed. Notable examples of this are to be seen at the Columbia mines where lateral dissemination carries zinc ore out in the limestone wall rock to the distance of several feet. While zinc carbonate is found in surface croppings, at very shallow depths the metal occurs as sulphide with occasionally a small amount of the oxide, zincite. The fissures, in the main, course a little east of north by west of south, with numerous secondary cracks and cross veins at a somewhat uniform angle of 59°. Along the line of the main veins much of the immediate wall rock is altered and checked and shattered into diamond shaped pieces with invariably this same angle of 59° and its supplement 121°. The alteration is of a character indicating unusual pressure with its consequent high temperature. Upon examination of the diamond shaped pieces, the compact limestone where weathered will exhibit thin and fragile edges of coral cups split across with a clean cut face, also crinoid stems split and cut at various angles and with no evidence of attrition. Some of these veins have a width of from 8 to 10 ft., the most of them being narrow, however, 12 in. or so in width. Within the vein walls there is but little country rock, the filling being firm and fully crystallized. Most of the veins contain a clear transparent fluorspar, giving a snow white appearance where granulated or shattered. In some veins, perhaps only those containing associated lead and zinc ores, the fluorite occurs (especially in open vugs) in well developed cubical crystals possessing all the various tints through purple, from a pale amethyst to an intense, almost black purple. These crystals represent the last product of crystallization and there is some evidence that this color is due to traces of certain metals found associated with the zinc and lead; possibly manganese. At the present time I am conducting an examination of the genesis of this colored fluorite. This presence of colored fluorite has become a guide to prospectors, for while zinc or lead may not be actually present, it will usually lead to zinc at some further depth. In fact there seems to be a sequence in this mineral deposit and generally the fissures have not been worked deep enough to reach zinc and lead ore. This sequence beginning with transparent or white fluorite, leads to a trace of lead; then comes colored fluorite with more lead and a trace of zinc. Following this, the fluorite gives place to calcite with more lead and zinc, and

finally zinc predominates with some lead and a mixed fluorite and calcite gangue. The Columbia mine near Marion, Ky., is by far the best known and developed mine operating. This seems to be at the center of the local upheaval, and has a 6 to 8 ft. fissure vein. The sequence if taken up at the surface with a showing of violet-colored fluorite and considerable of zinc carbonate, changes at a little depth to lead and zinc sulphides, the fluorite giving place to calcite. With increased depth the calcite or calc-spar, in turn diminishes, with fluorite disappearing almost entirely, and at a depth of 125 ft., the vein is uniformly zinc and lead sulphides from wall to wall, assaying from 30 to 50% metals. This sequence is in accordance with conditions at other mines in the district.

The Eagle Fluorspar mine near Salem, Ky., is now opened in a lower grade zinc ore with fluorite present to the extent of 50 to 60%, while some other fluorspar mines in the district are at the point where too much lead and zinc is present for high-grade fluorite and too little lead and zinc as yet for mining operation for these metals. It is probable that all the main fluorite veins (true faults) will lead at some considerable depth into lead and zinc.

This nature of deposit of zinc sulphide as the leading metalliferous mineral in fissure veins is, I believe, unusual and entirely different from the Missouri-Kansas, and Wisconsin districts, where the horizontal blanket or lens formation of the ore body exists. Nearer this Kentucky deposit in Arkansas, some similarity is met with in the way of more or less vertical leads, and it is not without significance to note the geographical proximity of all these mentioned districts, together with the central Missouri and southeastern Missouri deposits, which suggests a connected paragenetic system. This Kentucky-Illinois district is, however, peculiarly productive of fluorite and in this is unique and solitary. It presents many interesting geological and mineralogical features and will continue for many years to supply the entire demand for fluorite. A few deposits of zinc and lead ore may be developed very profitably, but on the whole the district can hardly be expected to compare with other producing fields of these heavy metals now being developed and worked.

The development of zinc operations is just beginning, there being but two mines opened and operated to any extent. The Eagle Fluorspar Co., with mines near Salem, in Livingston County, and the Western Kentucky Mining Co., operating the Columbia mines near Marion in Crittenden County, Ky. No zinc ore other than test lots has as yet been marketed or shipped.

Among the producers of fluorite in addition to the above named are the Kentucky Fluorspar Co., and The Fluorspar Co., the former having a crushing plant in the town of Marion. The usual profusion of unreliable promoters seems to have infested the district, but a sufficient number of solid companies are already in the field to assure development, and the immediate future will see a considerable movement of mineral from the district.

FULLERS EARTH.

THE mines of Quincy, Fla., continued to supply the greater part of the output in 1900, which amounted to 11,813 short tons, valued at $70,565, against 13,620 tons ($81,900) in 1899. There has been a steady decline in the production since 1897, when it reached a total of 17,195 tons, the highest in the history of the industry.

Deposits of fullers earth were exploited to some extent at Fairburn, S. D., and Parkdale, Colo., while new discoveries were reported in several States. The California Fullers Earth Co. was active throughout the year, but limited its mining operations until a market could be found. Arrangements were made at the close of the year to enlarge its plants to a capacity of 50 tons per day. The company states that its product is in general use on the Pacific Coast and also in the Southern States, where it is employed especially for the refining of cotton-seed oil. The fullers earth deposit is located about 16 miles north of Bakersfield in the Poso Hills. So far as prospected it covers an area of 160 acres and has a depth of 52 feet. The material is raised from an open pit on to a drying platform, where it is sun-dried for 24 hours and is then transported to the mill, where it is coarsely crushed, passed over a grizzly, and ground in a mill patterned after the ordinary roller process flour mill. The final product sells for about $15 per short ton f. o. b. Bakersfield for San Francisco and Los Angeles markets, while the prices at other points are governed by the quotations for the English product and the prevailing freight rates. It is expected that the shipments in 1901 will amount to at least 2,500 tons, as large contracts have been made to supply Missouri River packers.

The deposits at Quincy, Fla., occur between a stratum of plastic clay from 2 to 12 ft. thick, which in turn is overlaid by the surface soil. The layer of fullers earth varies from 2 to 12 ft. in thickness and rests upon sand. Occasionally a second deposit of the earth is found below the first. In mining, the overburden of sand and plastic clay is removed and the wet earth chopped out in thin slices with mattocks and sun-dried for several days. In this way the freshly mined, wet, greenish clay loses nearly half its weight, and becomes a cream white brittle substance containing 15% H_2O. Artificial dryers and crushers are now used in the preparation of the material for market, which is employed mostly in the refining of mineral oils and fats.

Imports.—The imports of fullers earth in 1900 were 2,431 long tons lump earth, valued at $14,750, and 5,742 long tons ground earth, valued at $50,047. In the previous year they amounted to 3,743 long tons lump ($23,194) and 6,577 ground ($46,446). Under the present tariff the duty is $1·50 a ton on lump earth, and $3 per ton on ground earth.

New York Market.—At the opening of the year prices were steady at 75@80c.

per cwt. for lump, 75@90c. for powdered and $1·25 for refined lump, with fair demand and short supplies. In February and March, several large shipments were received from London and Southampton, but as the greater part was for immediate consumption they had little influence on the market. The demand throughout the spring and summer months was strong at unchanged quotations. In the latter part of the year, the market became rather quiet.

Uses.—The primary use of fullers earth was for fulling wool, but it now finds extensive employment for deodorizing and decoloring fats, oils and greases. All refiners of lard, cottolene and similar products, on a large scale, including such concerns as N. K. Fairbank Co., Swift & Co., Armour & Co., Nelson Morris & Co., Cudahy Packing Co., and G. H. Hammond & Co. are important consumers. The method of using fullers earth for this purpose varies somewhat according to the installation. Animal oils are usually run hot from the rendering tanks into the mixer. This is an open tank in which a small quantity of the earth has been placed. Here the materials are thoroughly mixed until they assume the consistency of thin putty, being heated meanwhile by steam coils. The mixture is then hydraulic pressed in filter presses, the oil leaving the mass in a clarified state and the impurities originally present in the crude oil being retained in the earth. In the treatment of lard, cottolene and butterine, for which English material is largely used, the process must be repeated. With mineral oil, the common practice is to dry the earth, after grinding to 60 mesh, and to place it in long cylinders through which the crude dark oils are allowed to percolate very slowly. At first the oil comes out perfectly water white, but soon assumes a shade of increasing intensity. When a certain maximum of color is reached the process is stopped and a new supply of earth must be used. Vegetable oils are heated in large tanks to a temperature above 100°C., and from 5 to 10% by weight of fullers earth is added. After stirring vigorously for 20 minutes the mass is filtered off through bag filters. The fineness of the ground fullers earth, the temperature during treatment, and the original refinement of the oil have an important bearing on the efficiency of the bleaching. The oil which runs first from the filter is not only much lighter in color, but has a lower specific gravity. Experiments have shown that a separation of oils can be made by this means which is comparable in many respects with distillation results. The purifying quality of fullers earth is exhausted with one mixing, and the waste earth is utilized as a dryer and filler in the manufacture of fertilizers.

Characteristics.—While fullers earth is a variety of clay, it differs from kaolin in that its usually high content of silica is not accompanied by a corresponding decrease in the percentage of water in the sun-dried material. Samples of fullers earth containing from 65 to 70% Si_2O, and 20% or less of total bases (Al_2O_3,Fe_2O_3,CaO,MgO,K_2O,N_2O) when sun-dried yield from 15 to 25% H_2O. Kaolin containing 40 to 50% SiO_2, and from 30 to 40% total bases may contain 10 to 15% H_2O when sun-dried, but with a content of 70% SiO_2 the water in kaolin becomes very low. About one-half of the water in sun-dried fullers earth may be expelled by prolonged heating in a water bath, the remainder passing off only at a much higher temperature. It usually possesses greater adhesive-

ness when touched to the tongue than other clays, and when immersed in water, it lacks plasticity and disintegrates into gelatinous flakes. The detergent quality is the best means of distinguishing it, yet in addition it should crumble easily when placed in water, so that prompt diffusion of its particles will result, giving a fine product that will not wear the fiber. While the characteristics mentioned above are sufficient for identification, mineralogists have endeavored to isolate fullers earth by its composition. Dana states that it is in part kaolin and in part the hydrous silicate smectite. It is probably an alteration product formed like kaolin in the decay of rocks, and found *in situ,* or else redeposited in sedimentary series.

The material from Ballert Point, near Tampa, Fla., contains chalcedonized shells, corals, etc., which leads to the suggestion that it is probably ordinary clay, that has received an additional supply of silica from infiltering solutions. At the present time, the name "fullers earth" is applied to any form of clay which possesses the special properties above stated, and has the power to absorb liquids in large quantity; particularly when it acts similarly to bone-black in the removal of coloring matter from oils. The discovery in 1893, of the fullers earth deposits at Quincy, Fla., was due to the unsuccessful effort to burn the material into bricks. In place of yielding a hard coherent mass, the clay exfoliated, and attention was then attracted to its resemblance to the German product. The material has practically replaced bone-black in the filtration of many mineral oils although the English variety is preferred for the cotton-seed and lard oils. Its value for clarifying purposes has lead to a widespread search and samples of numerous deposits have shown its occurrence in Florida, California, Indian Territory, Nebraska, Colorado, New Mexico, Georgia, Pennsylvania, South Dakota and New York. The physical properties of the samples from different localities vary greatly. The North Carolina and Virginia material is more or less sandy; the Georgia product is almost identical in appearance with the Florida earth although neither resembles the earth imported from England. The South Dakota product, however, is almost the exact duplicate of the English variety.

ANALYSES OF FULLERS EARTH FROM VARIOUS LOCALITIES.

Components.	Bakerfield, California.	Quincy, Florida.	River Junc. Florida.	Norway, Florida.	Ocala, Florida.	DecaturCo. Georgia.	Valentine, Nebraska.	Fairburn, So. Dakota.	Custer, So. Dakota.	Hermosa, So. Dakota.	Enid, Oklahoma, I. T.	Cilly, England.	Reigate, England.	Malthite, Steindoer'l.	Blue Earth, England.	Yellow E'th England.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
SiO_2	54·32	62·88	50·70	54·60	56·73	67·46	47·37	58·72	55·55	55·40	50·36	51·21	53·00	50·17	52·81	59·37
Al_2O_3	18·88	10·35	21·07	10·99	27·78	10·08	7·08	16·90	18·58	27·70	33·38	12·25	10·00	10·66	6·92	11·82
Fe_2O_3	6·50	2·45	6·88	6·61	3·21	2·49	3·89	4·00	3·82	1·80	3·31	2·07	9·75	3·15	3·78	6·27
CaO	1·00	2·43	4·40	6·00	0·87	3·14	32·19	4·06	3·40	2·30		2·13	0·50	0·25	7·40	6·17
MgO	3·22	3·12	0·30	3·00	0·64	4·09	1·19	2·56	3·50	0·70		4·89	1·25		2·27	2·09
H_2O		7·72	9·60	10·30	7·38	5·61	2·53	8·10	8·80		12·05	27·89	24·00	35·83	14·27	13·19
Na_2O	4·21	0·20					Tr.	2·11		0·49	0·88			5·00		
K_2O		0·74			0·42		0·98			0·59					0·74	0·84
SO_3							0·20								0·05	0·07
CO_2							17·73									
P_2O_5					5·54		0·21								0·27	0·14
TiO_2					1·27						Tr.					
NaCl															0·05	0·14
Moisture	11·86	6·41	7·90	7·45		6·28		2·30		13·00						
Vol. Matter									5·35							
Org. Matter					3·61						Tr.					

GARNET.

THE production of garnet in the United States in 1900 was 2,980 metric tons (3,285 short tons) valued at $92,801, against 2,327 metric tons (2,565 short tons) valued at $72,672 in 1899. The North Creek mines in the Adirondacks furnished 2,508 tons against 1,656 tons in the previous year, the remainder in each year coming from Chelsea, Pa., and Roxbury, Conn. The mineralogical character and the probable geological history of the Adirondack deposits were given in THE MINERAL INDUSTRY, Vol. VI.

The value of garnet for abrasive purposes consists in the proper combination of hardness, brittleness and cleavage. In use the grains are affixed to paper, and while they should possess hardness for ease in abrading substances against which they are rubbed, at the same time they should be brittle so that the wearing of the grain will take place by the continual breaking off of small particles from each individual grain, ever presenting fresh and sharp cutting edges so essential for effective work. Should the garnet lack brittleness, the original sharp edges of the grains will rapidly wear smooth and lose their cutting quality. The superiority of garnet to quartz as an abrasive is probably due to the easy cleavage and, though more costly its durability makes it preferable for special purposes. The crushed and washed material is graded into many different sizes and, when attached to paper, is known in the trade as sand paper, garnet paper or shoe paper—products that are extensively used in the manufacture of boots and shoes and to a limited extent in wood working. As in previous years practically all the garnet used in the sand paper trade was mined in New York and Connecticut, the latter State supplying the shoe paper trade, with the exception of a small amount from Pennsylvania. During the past year a new property was opened up near Roxbury Falls, Conn., by a Western concern which has recently commenced the manufacture of sand paper. Considerable shoe paper was exported and the demand for wood working purposes, though small, has increased. The mineral for the wood working paper is mined in the Adirondacks and, while foreign stock has been marketed at a lower figure, it is of inferior quality. Garnet from other localities has been tried and though as hard as the Adirondack mineral it was not satisfactory for finishing wooden surfaces. A manufacturer of paper-mill machinery has recently used garnet in place of emery for grinding ironwork joints where the mineral is confined between two surfaces. In comparison with emery, only one-half of the weight of garnet was required and a perfect joint was secured in one-half the time.

GEMS AND PRECIOUS STONES.

THE most important feature in the mining of gems and precious stones in the United States during 1900 was the success attained by the New Sapphire Mining Syndicate, which greatly increased its output of sapphires from the mines at Yogo, Mont. As usual there was a small production of turquoise in New Mexico and California, and of rubies and sapphires in North Carolina. Among foreign countries Persia, Burma, Siam, South Africa, and Colombia continued to be the main source of supply of the most valuable gems.

DIAMONDS.—*Africa.*—The report of the De Beers Consolidated Mines, Ltd., for the fiscal year ending June 30, 1900, shows that the total output of diamonds during that period was sold for £2,070,414. The profits, after deducting expenditures amounting to £1,616,217, were £454,196. From the De Beers mine there were hoisted 1,081,115 loads of blue ground, from the Kimberley mine 592,549 loads, and from the Premier mine 980,210 loads. The total quantity of material washed at the De Beers and the Kimberley mines was 1,522,108 loads, which yielded 1,000,964 carats, or an average of 0·67 carats per load, while at the Premier mine 1,662,778 loads were washed, yielding 496,762 carats, or 0·30 carats per load. The diamonds from the Premier mine realized the sum of £567,360, or 22s. 10d. per carat, against 20s. 9d. per carat for the preceding year, and the diamonds from the De Beers and the Kimberley mines £1,794,222, or 35s. 10d. per carat, as against 29s. 7d. in the previous year. A new agreement for the sale of the company's output of stones at an increased price was entered into on the 20th of April, 1899, which covers the period from April 1, 1900, to July 31, 1901. During the year the company purchased the claims, machinery, etc., of the New Bultfontein Mining Co. for the sum of £192,862, which transaction will greatly facilitate the working of the Bultfontein mine. The operations of the company were seriously hampered in consequence of the Transvaal war, and it was thought best to defer the usual dividends. A large sum, however, amounting to £1,493,326, was written off the profit and loss account against the assets of the company. During the siege of Kimberley by the Boers, the pumps in both mines were kept going and no damage was done to the underground or surface plant. New discoveries of diamonds were reported in 1900 from the May district of Cape Colony, and from the Kamemtka River, a tributary of the Sanacka, in the Russian Urals. The Transvaal and Orange Free State mines were inactive, owing to the Boer war.

Australasia.—Diamond mining in New South Wales during the latter half of 1899 was greatly hampered by the recurrence of the water famine, which has

annually visited the fields for several years past. The output amounted to 25,874 carats, valued at £10,350, derived almost entirely from the Boggy Camp Field, 11 miles west of Tingha. Owing to the scarcity of water, mining in the Bingara field was confined almost entirely to exploration work. The principal mines operated in the Tingha field are the Invernell Diamond Fields, Ltd., The Soldiers' Hill Co. and the Australian Diamond Fields, Ltd. The first mentioned has a very complete and modern diamond washing and saving plant with a capacity of 300 cu. yd. per eight hours. Water is taken from the Gwyder River over a mile distant.

South America.—In Brazil there has been a revival of the diamond mining industry owing to the Transvaal war. It is almost impossible, however, to form an accurate estimate of the present production, as the State places a duty of 16% on the valuation in addition to the 1% tax demanded by the municipal government with the consequence that only a small proportion of the diamonds and carbons are declared. The value of the exports from Minas Geraes during the first half of 1900 were reported at 255,000 milreis ($140,000). Mr. A. de Jaeger estimates the total production of Brazilian stones at 12,000,000 carats, valued at $100,000,000. In 1880 the State of Minas Geraes yielded 5,000 carats, but subsequently the output fell off to a few hundred carats. The most noted specimens from the Brazilian mines are the "Southern Star," which weighed 253 carats in the rough, and the "Dresden" of 117 carats, both of which came from Bagagem.

The diamondiferous deposits of British Guiana attracted considerable attention in 1900, and efforts were made to find the original matrix of these valuable stones. Early in the spring a shipment of 282 specimens was made to London valued at the high figure of $12 per carat. Later in the year, 400 small stones, ranging up to 1·5 carat in weight, were brought to Georgetown. The locality of the deposits is about 250 miles up the Mazaruni River, a journey of from 12 to 20 days from Georgetown. The diamonds are found in a formation consisting of sandy pulverulent clay mixed with rounded and subangular pebbles and nodules of ironstone, of pieces of quartz, felsite and ironstone conglomerates with much ilmenite sand, rounded pebbles of schorl, pleonaste, small, white and faintly colored corundum and topaz. Digging has been carried to 7 ft. below the surface, and from 150 cu. yd. over 1,000 small size stones have been extracted of a generally pure color and water and shape, the largest weighing, perhaps, 2 carats. In another part of the diggings 100 cu. yd. yielded over 1,000 stones. The gravels here are remarkable for the large number of transparent quartz crystals free from any trace of erosion. The district is heavily forested and is fairly healthy, though subject to frequent rainfall.

Diamondiferous Deposits in the United States.

By Wm. H. Hobbs.

The occurrences of diamonds in the United States seem to be largely confined to three regions, *viz.:* the stretch of country southeast of the Appalachian Mountain system between Virginia and Georgia, the belt west of the Sierra Nevada

and Cascade ranges in California and Oregon, and the region bordering upon the Great Lakes of the Laurentian system.

Piedmont Region of the Southern Appalachian.—In the southern portion of the Piedmont plateau 18 diamonds have been found and identified, most of them ranging from a fraction of a carat in weight to a little over 4 carats. One, however, the "Dewey" diamond, found at Manchester, Va., in 1855, weighed before cutting 23·75 carats, and it is the largest diamond that has been found in the United States. In North Carolina diamonds have been found in Burke, Rutherford, Lincoln, Mecklenburg, Franklin and McDowell counties. From South Carolina one diamond has been reported, but upon rather unsatisfactory evidence since the stone has been lost and there is no evidence that it was ever examined by a competent mineralogist. In Georgia, diamonds have been found, it is claimed, in Habersham, White, Banks, Lumpkin, Hall, Forsyth, Gwinnett, Cabb, Clayton, Bartow, Carroll and Haralson counties. Nearly every diamond from this region of which a definite report has been made has an octahedral crystal form, though this is modified in some instances, as in the Dewey diamond, by combination with the trisoctahedron. One hexoctahedron has been reported.

The diamonds are found in loose gravels and there can be little doubt that they are derived from the disintegration of the crystalline rocks in the Appalachian ranges to the northwest. Among the numerous types here represented are included ultrabasic igneous rocks and itacolumite, which latter in Brazil is diamondiferous but here is apparently barren.

The Pacific Slope Region.—Like the region just described the California-Oregon region is one of placer gold mining, and it is in connection with this industry that the diamonds have been found. The earliest finds date almost as far back as the discovery of gold, the former State Geologist, J. D. Whitney, and the State Mineralogist, Henry G. Hanks, being the authorities for the determination of the stones as diamonds. Mr. Geo. F. Kunz* mentions 30 stones which have been found and for which the identification seems tolerably satisfactory. A considerable number of others have been reported whose identity has not been established. The introduction of gravel stamp mills and the use of mercury to recover the gold from the sluices have been alike unfavorable to the discovery of diamonds, but fragments of diamond crystals continue to be reported in the tailings from the stamps.

H. W. Turner, in his paper on "The Occurrence and Origin of Diamonds in California,"† reviews the reports of Whitney and Hanks and on their authority enumerates 12 localities in Eldorado, Amador, Nevada, Butte, Trinity and Del Norte counties, at which diamonds have been found. From one of these localities, Cherokee Flat in Butte County, no fewer than 56 stones were found according to Whitney. Of more recent finds, Turner reports 14 stones from the vicinity of Placerville, Eldorado County, a number from Plumas County, one from Tulare County, five from Oroville in Butte County and five from other localities. Of the recent Placerville finds two stones have been described by Kunz.‡ Each of these stones is nearly a quarter of an inch in diameter, the

* Gems and Precious Stones of North America. New York, 1890. pp. 24-30.

† *American Geologist.* Vol. XXIII., pp. 182-191, March, 1899.

‡ *16th Annual Report United States Geological Survey*, Point iv., p. 596.

larger one being of a greenish hue and the smaller one pale yellowish. The diamonds of the Pacific Slope are found in the auriferous gravels, and there can be but little doubt that they are derived from the crystalline rocks in the ranges to the east. All the localities in which diamonds thus far have been discovered are in the vicinity of serpentine masses, a fact which suggests an origin possibly similar to that of the South African diamonds.

The Great Lakes Region.—In the region bordering upon the Great Lakes 17 or more diamonds have been found at eight widely separated localities within the States of Wisconsin, Michigan and Ohio. In Wisconsin the diamonds occurred at Plum Creek, Rock Elm township, Pierce County, Oregon in Dane County, Eagle in Waukesha County, Kohlsville in Washington County, Saukville in Ozaukee County and Burlington in Racine County. In the two remaining States diamonds were found at Dowagiac in Cass County, Mich., and at Milford in Clermont County, Ohio. All these localities are included in the drifted area and in or near the "kettle moraines" of the later glacial epochs. It is also worthy of note that all save the Michigan locality are on or near the outermost fringe of these moraines. This is believed to indicate that the diamonds which have been found and those which still lie buried in the drift, have been brought from their earlier home through the agency of the ice mantle at the time of its later invasion of the territory of the United States, and probably also at the time when it occupied its most advanced position. I have given this view in my paper on "The Diamond Field of the Great Lakes,"* and if it is correct there is much probability that the area in which was the early home of the lake diamonds may be located in the wilderness to the eastward of James Bay in the Dominion of Canada. The evidence for this is derived from a study of the ice scorings on the rock exposures within the glaciated territory and it will be augmented so soon as scientific exploration of the Hudson Bay region supplements the few data now available regarding ice movement in that territory.

Unlike the diamonds from the other areas in the United States those found in the Lake region are large. With the exception of the Plum Creek specimens, which were quite small, they range in weight from 2·0625 to 15·375 and 21·25 carats, the respective weights of the Eagle and Kohlsville diamonds. This larger size is doubtless explained by the fact that placer gold mining has been but little resorted to in the region in question, though the minute Plum Creek specimens were discovered in this way. The other specimens were discovered quite accidentally and stones of less than two carats' weight would therefore be expected to escape detection.

In none of the three diamond producing regions of the United States do the prospects warrant any mining operations carried out solely for the purpose of obtaining diamonds. In the southern Piedmont and in the Pacific Slope regions diamonds will continue to be found in connection with the placer workings for gold, and it is to be expected that diamonds will also occasionally be discovered in the kettle moraines of the Lake region, but workable deposits can only be looked for in the homes from which the stones have been carried. Because of the indications of an abundant source the Canadian locality offers the most

* *Journal of Geology*, Vol. VII, pp. 375–388, May–June, 1899.

promise of success, but the time is yet hardly ripe for prospecting in the region for diamonds.

In addition to the three regions described above, the State of Idaho should be mentioned in which a number of small diamonds have been found in connection with the gold placers. In this region is perhaps to be included Blackfoot in Deer Lodge County, Mont., from which place Kunz reported the occurrence of an octahedral diamond in 1883.*

EMERALDS.—The lease of the celebrated emerald mines of Muzo and Coscuez, Republic of Colombia, held for the past eight years by Mr. Macini, and transferred by him to an English mining company, expires July 15, 1901. The Government proposes to grant the concession, including rights of exploitation, use of buildings, etc., to the highest bidder for a term of 15 years. The concessioner must pay to the Government a premium not less than $200,000 gold and an annuity, the amount of which should be named in the bid. The Muzo mines were discovered in 1555 by Lancheros. Mining was begun in 1568 and has been continued ever since. No record exists of the quantity or value of the stones produced, although fortunes have been made for generations of leaseholders. The gems occur in isolated crystals or in lodes with calcite and parisite in a bituminous limestone of the Lower Cretaceous age, lying on a Triassic sandstone. The mine has the form of a tunnel 100 yards wide, with very inclined walls. Near the mouth are several very large reservoirs, the water of which is controlled by a system of gates. The overlying barren rock is cut out in benches and falls to the bottom and when this begins to fill, the water is turned on and the rock swept away. This operation is repeated until the limestone is laid bare, when the gems are carefully broken out.

A large amount of exploration work has been done in the Emerald deposits of New South Wales which are located at Butler's Reef, 10 miles from Emmaville. Some of the gems which were sent to England were highly praised, but the work has not been profitable.

D. A. MacAlister† describes what are known as the emerald mines of Cleopatra which lie in the mountain range extending a long distance parallel to the Red Sea within a few miles west of its coast, in a latitude a little south of Eofu, on the Nile. The mines of the Northern Etabi seem to have remained untouched since their desertion after the fall of Rome. The workings are small passages burrowed in the emerald bearing schists, sometimes extending for a long distance. Many scattered ruins are there in which no doubt the mining population lived and the differences in style among them suggest they were occupied for a long time.

GARNET.—The garnetiferous deposits of Bohemia from which for years the world's supply of garnet was produced occur in the hilly Cretaceous district in the northeastern part. Of late the industry has been subject to many changes and the South African pyropes or "Cape rubies" have been in such greater demand that nearly all of the Bohemian workings have been abandoned except the extensive open pits at Podseditz. The South African garnet is obtained in the washing of the blue ground in the diamond district. It is possible that the

* *America*, pp. 30–31.

† *Geographical Journal*, November, 1900.

Bohemian industry will be revived, particularly if started on a large scale with improved mechanical methods, as the deposits cover an area of 27 sq. miles and a portion of it only has been worked. According to Hans Oehmichen a tenth of this district is exceedingly rich. The Bohemian garnet is of a fine, rich dark-red color sometimes passing into jacinth-red and occurs exclusively in grains of various sizes. It is classified as a magnesian alumina garnet containing lime, iron, manganese and chromium oxides. Distinct crystals are rarely found. The specific gravity ranges from 3·69 to 3·72, and the larger grains average 0·44 g. in weight as a rule, although some have been recorded 1·5 in. in diameter.

Opal.—The White Cliffs Opal Mining Co., Ltd., operating the opal fields in the Albert mining district of New South Wales is practically the largest producer of noble opal. This field has increased its production and the value of the output for 1899 has been estimated at £135,000 as compared with £80,000 in 1898. During the middle of 1899 the number of miners was increased to over 1,000, with the result that an augmented quantity of opal was produced, causing a temporary glut on the market. During the last quarter of the year many miners left the field owing to the fall in prices, and the number was reduced to 750 by the end of 1899. The White Cliffs Opal Mining Co., Ltd., which had 350 tributors working in their district in August, dismissed 300 of them, and other lessees followed the same course. It was expected that in 1900 the present surplus stock would be absorbed and higher values restored, particularly as the demand for the finer qualities is increasing. The nature of the product and the uncertain and at times limited demand for it must always render the market liable to be overstocked. The water supply, ever a source of great anxiety, will be greatly improved by the government tank which is being constructed a mile south of White Cliffs on the Wilcanna Road. The great difference in price between the various classes of opal, together with the fact that opal buyers do not as a rule record the weight of the purchase, renders the estimate of production very difficult. The weight of the output in 1899, however, from the post-office returns of opal parcels that passed through the mail, was 2,795 lb. avoirdupois. As to the outlying portions of the White Cliffs opal field, three-fourths of the miners employed on the Bunker Creek diggings, 12 miles from White Cliffs, have ceased operations and practically no attempt has been made during the year to extend the mining beyond the central field.

The value of the production in Queensland in 1899 was £9,000, an increase of £355 above the value of the previous year's output. This advance is rather remarkable as the district was parched for a great part of the time and the price of the stone had decreased.

Ruby.—The Burma Ruby Co., Ltd., has declared a dividend for the year ending February 28, 1900, of 12·5%. After payment of rent and £9,943 to the Government there remains £25,050 available for the shareholders. During the year 818,135 loads of earth have been washed as compared with 652,456 loads in the previous year and £84,000 was received from the sale of stones. The company apparently controls all of the known ruby ground in Burma, and the mines are estimated to produce more than one-half of the world's output. A part of the ground included in the concession is worked by natives, from 1,000

to 2,000 of whom are licensed to dig for rubies; each native paying a royalty of 20 rupees (about $6) per month. The income derived from this source is large, being usually more than enough to cover the rent paid to the Indian Government for the concession. The rubies are obtained from the alluvial ruby earth (*byon*) of the Mogok Valley. For a time the company was unable to work this earth at a profit, and an attempt was made to reach the source of the rubies by tunnelling into Pingutoung Hill. This hill is said to be of volcanic origin with an extinct crater at the summit. The rubies were supposed to occur in the volcanic pipe, similar to the occurrence of diamonds in the Kimberley mines, but the work proved unsuccessful and operations upon the hill were abandoned. Work is now being directed to the alluvial deposits, which the company is able to treat successfully owing to the use of powerful pumps for the removal of the water. The natives have in the past treated most of the surface *byon,* and the company is now treating those portions of the deposit which are below the original surface. About 6 ft. of the surface material is removed and the ruby bearing earth extracted by open cuttings. None of the excavations is as yet more than 40 ft. deep, but with improved machinery the depth will probably be extended even to bed rock, where it is supposed the largest and best rubies will be found. Formerly the richer material only in small quantities was treated, but experience has shown it is better to wash the whole of the *byon.* The productive area of the valley contains approximately 20,000,000 loads of ruby-bearing ground. Estimating on the 11-months' work ending January 31, 1900, the average value per load was 50c., and the cost per load 27c., leaving a profit of 23c. per load. Although large stones are rare, several of fairly large size have been found by the Burma Ruby Co., Ltd., during the past few years. One weighing 28 carats in its natural state and 18·5 carats after cutting, was recently sold for a large sum. Other large stones are now being cut. In the trade rubies are divided into eight classes, according to their size and color.

SAPPHIRE.—Of the Eastern countries, Siam furnishes the finest sapphires, the gems approaching closely to the cornflower blue that is so highly prized. The most important mine is in Battembong district of Pailin. The sapphire-bearing stratum consists of clay and gravel and has a thickness of about 2 ft. The material is mined by pits, washed and the sapphires picked out by hand. Dark sapphires are found in Upper Burma associated with rubies, while Ceylon and Cashmere furnish paler crystals that are brilliant and effective as gems. In Victoria, Queensland and New South Wales large sapphires are frequently found in the auriferous gravels, but they possess usually a very dark color. Recently the "New Mine" sapphires from Montana have acquired recognition in the gem markets, and are by far the most valuable of the precious stones mined in the United States. The mines are located in Fergus County, Mont., 13 miles west of the town of Utica. Their discovery was made in 1895 by a placer mining company while engaged in working the bench gravels of Yogo Creek. It was believed at first that the gems came from the gravel, but it is now known that they occur in a dike of trap rock cutting limestones, which extends for a distance of 5 miles from the canyon of Yogo Creek. The material of the dike varies from the hard igneous rock to a soft yellow clay which is its decomposition

product. The soft material is washed into sluice boxes and the gems caught upon riffles, while the harder rock is first exposed to the weather for a year or more before washing. Owing to the severity of the climate surface operations can only be carried on during the summer months. The gems are brilliant in luster, range in color from steel blue to cornflower blue and are quite free from cloudiness. It is stated that as much as $75 per carat is obtained for the finest stones. The New Sapphire Mining Syndicate which operates the mines had a very successful season, the yield of gems far exceeding that of previous years. A tunnel and double compartment shaft which will greatly facilitate operations were among the year's improvements.

TURQUOISE.—The turquoise mines of Persia which yield the finest gems are located about 35 miles from Nishapour, in the Khorassan. The region is mountainous and the mines are from 5,000 to 6,000 ft. above sea level, lying on the southern slope of the summit of the range. They are controlled by a local firm which pays an annual rental of $14,000 to the government. At present only one mine is in full operation, with a weekly output of gems valued at about $400. The manner of working is very primitive. The miners reach the shaft through an inclined tunnel and from this point have to clamber down as best they can. The rock is broken by picks or by blasting and is then hoisted in a goatskin bag attached to a wooden wheel which is turned by two men. At the surface the rock is crushed by small hammers and the stones picked out by hand. Besides the underground mines there are surface diggings (khaki) extending a mile or more over the plain at the foot of the mountain. Work here is carried on by women and children who simply dig up and look over the earth. Not many first water stones are found at present; such as are discovered are immediately bought up by the wealthy Russians and Persians.

New discoveries of turquoise were made at Weckersdorf, Thuringia, and near La Barranea, Sonora, Mexico.

S. L. Penfield* discusses the probable composition of turquoise, this mineral being regarded by some mineralogists as made up of an aluminum phosphate colored by a copper salt. Mr. Penfield regards turquoise as a derivative of orthophosphoric acid in which the hydrogen atoms are replaced to a large extent by a univalent radical, the small amounts of copper and iron being regarded as constituents rather than impurities; therefore the composition of the mineral may be expressed by the formula $[Al(OH)_2, Fe(OH)_2, Cu(OH), H]_3PO_4$.

TOURMALINE.—Some work was done during the year in a tourmaline mine in San Diego County, Cal. It is stated that the gems obtained were of excellent color and of sufficient size to command a good price. They are found in a dike of granite 50 ft. or more in width, made up of lepidolite, spodumene, feldspar and quartz. The tourmalines range in color from water white to dark pink and some also show varying shades of green.

* *American Journal of Science*, November, 1900.

GLASS.

By Robert Linton.

The physical and chemical properties of glass, its classification, manufacture and metallurgy have been fully discussed in my article on this subject in The Mineral Industry, Vol. VIII., and reference should be made thereto for details of general technical importance. The following article embraces the industrial conditions of the production of glass in the United States in 1900, and a brief review of the progress in its manufacture for that year.

Plate Glass.—*Production.*—According to the statement made by John R. Pitcairn, President of the Pittsburg Plate Glass Co., before the United States Industrial Commission, out of the total of 13 plants with 61 furnaces and 1,204 pots and a total annual capacity of 31,866,000 ft., there were in operation on December 20, 1900, 12 factories with 37 furnaces and 900 pots. The sales for 1900 (December estimated) amounted to 18,796,146 ft.

Prices for plate glass from 1875 to 1900 were as follows:

Size.	1875.	1880.	1885.	1890.	1895.	1900.
1 to 3 ft.	$0·71	$0·51	0·46	$0·40	$0·30	$0·31
3 to 5 ft.	0·84	0·61	0·55	0·48	0·36	0·38
5 to 10 ft.	1·12	0·80	0·72	0·64	0·48	0·60
10 to 25 ft.	1·49	1·06	0·96	0·85	0·63	0·81
25 to 50 ft.	1·56	1·11	1·01	0·89	0·66	0·85
50 to 100 ft.	1·66	1·21	1·09	0·97	0·72	0·90

The total productive capacity and actual output of the world for 1900 in square feet is given in the subjoined table:

WORLD'S CAPACITY AND OUTPUT OF PLATE GLASS. (IN SQUARE FEET.)

Country.	No. of Factories.	Capacity.	Output.
Austria	2	2,300,000	1,100,000
Belgium	9	24,700,000	12,400,000
France	8	15,300,000	7,800,000
Germany	8	14,700,000	6,600,000
Italy	1	800,000	800,000
Russia	4	3,200,000	3,200,000
United Kingdom	4	7,900,000	7,900,000
United States	13	31,866,000	18,796,146
Total	49	100,766,000	58,596,146

In the period of the last advance, the cost of raw materials has increased about 85% and wage cost has also been augmented, so that the gradual lessening of the cost of the product is a tribute to the improved technical supervision of the industry. The large capital absolutely necessary to enter into the plate glass business acts to prevent a very rapid increase in the number of factories, especially when the present capacity of the country is so much above the consumption. There are nevertheless four new works in the course of erection, *viz.:* Allegheny Plate Glass Co., Hite, Pa., Heidenkamp Mirror Co., Springdale, Pa., Saginaw Plate Glass Co., Saginaw, Mich., and Sieberling Plate Glass Co., Ottawa, Ill. Should these be put into full operation the production would be very much greater than the demand.

Window Glass.—There are at present 109 window glass factories with a total capacity of about 2,900 pots. This pot capacity would produce about 250,000 boxes of 50 ft. each weekly, and as window glass factories do not operate in the United States during the summer months on account of the heat, a maximum run of 40 weeks would produce about 10,000,000 boxes. There are, however, not enough blowers available to man the entire plant capacity; probably not over 7,000,000 boxes could be produced with the blowers available. As the consumption is something over 500,000 boxes monthly, it will be seen that the present productive capacity of the United States is more than sufficient to meet the demand.

Cathedral, Rough Plate, Etc.—There are 11 factories with a total capacity of 272 pots which produce rolled cathedral, rough plate, skylight, and tile. The art windows that are being made by our leading firms are unsurpassed in tastefulness of design and execution.

Tableware, Tumbler and Plate Glass.—There are 36 tableware, tumbler and cut glass factories with a capacity of about 1,000 pots. The tableware factories, especially in the pressed ware line, are producing a very fine quality of glass, whose superiority is recognized abroad, a fact that is best evinced by the considerable increase in export business in this line. There are about 600 pots devoted to the manufacture of specialties. Lamps and globes form an important line of many of the flint glass works noted above. There is a capacity of 367 pots devoted to the manufacture of lamp chimneys.

The tendency toward centralization which prevails in all branches of business at the present time extends also to the glass industry, and while there is no branch of it that is absolutely monopolized by any one corporation, still in nearly all of them, large companies formed by the unification of smaller concerns, dominate business conditions to a greater or less extent. The Pittsburgh Plate Glass Co. owns 940 pots of the total of 1,204; the American Window Glass Co. owns 1,656 pots out of a total of 2,900, and of the balance the Independent Glass Co., a syndicate composed of various manufacturing companies, controls 874 pots. In the tableware branch numbering about 1,000 pots, the National Glass Co. owns 542 pots, and the United States Glass Co., 209. In the chimney branch the Macbeth-Evans Glass Co. owns 200 pots out of the total of 367. These large companies represent the leaders in their respective branches, both in business organization and management, and in the technical advancement of the industry.

IMPORTS AND EXPORTS.—The imports of glass and glassware for 1900 showed an increase over 1899, and the increase in exports was lower than that of the imports. The imports and exports for the last 5 years are given in the subjoined table:

UNITED STATES IMPORTS AND EXPORTS OF GLASS.

Year.	Imports.									Exports.
	Cylinder, Crown and Common Window Glass. (Unpolished.)		Cylinder and Crown Glass. (Polished.)		Plate Glass.		Glassware.	All Other.	Total Value.	Total Value.
	Lb.	Value.	Sq. Ft.	Value.	Sq. Ft.	Value.	Value.	Value.		
1896.....	54,870,782	$1,120,158	3,206,310	$942,431	2,187,983	$470,206	$441,230	$2,882,432	$5,856.457	$1,129.013
1897.....	49,963,483	1,029,867	3,551,160	903,519	1,343,987	282,440	513,400	1,858,383	4,587,609	1,250,137
1898.....	46,903,917	1,208,559	3,373,639	660,445	811,936	152,943	346,021	1,736,577	4,104,545	1,302,787
1899.....	47,483,193	1,383.911	2,271,914	449,886	1,061,536	239,820	436,398	1,972,774	4,482.789	1,728,022
1900.....	42,378,671	1,340.199	2,342,544	554,955	2,181,492	524,007	472,122	2,088,904	4,980,187	2,057,247

PROGRESS IN THE MANUFACTURE OF GLASS IN 1900.

It is a comment frequently made upon the glass industry, that it has remained considerably behind most of the other chemical and metallurgical industries in the matter of technical advancement. More attention is now devoted to this subject, the aim being to build up plants of greater permanent efficiency, to give especial attention to the improvement of small details, to achieve economy in small things and to raise the standard of quality of the glass. In the manufacture of fruit jars, bottles, lamp chimneys and some other articles of a similar kind, blowing machines have been recently introduced and are being so rapidly perfected that their use will probably become general within a short time. Improvements are being constantly made in machines for the manufacture of pressed ware, especially novelties. In the manufacture of window glass and bottles, continuous melting is rapidly supplanting the intermittent operation of the old style pot furnaces. The continuous melting regenerative tank furnace, even after its success had been demonstrated, was for a long time considered merely as an experiment by many of our best manufacturers, but at present it is preeminently the standard furnace. In the window glass branch alone within the past two years 16 new tank furnaces with a total capacity of 420 pots have been put into operation, which represents almost the entire expansion of the industry in that time. The regenerative type furnace, with periodic reversal of the firing, is built in preference to the so-called "recuperative" type, where there is no reversal of the firing, the heat of the outgoing waste gases being imparted to the ingoing air by transmission through thin flue walls. With these improved furnaces it is of interest to know how much greater is their efficiency than that of the old style. In any case the amount of heat that is actually absorbed in bringing about the chemical reactions of glass melting bears a very small proportion to the whole amount developed by the combustion. But while in the old style pot furnaces it amounted to only from 4 to 5%, in the continuous tank furnaces it amounts to from 10 to 12%. The rest of the heat developed cannot be considered as actual waste. The amount required to keep the furnace hot and the amount lost by radiation from those parts of the furnace that must be kept well

ventilated in order to prevent too rapid wear, are necessary to the operations and should be considered as heat utilized. What interests the manufacturer is to furnish the necessary heat only and to prevent waste beyond that amount. Recent calculations of Emilio Damour, of the École des Mines, Paris, upon the thermal efficiency of various styles of glass melting furnaces show better than can be indicated in any other way, the economy of the tank furnaces. Based on a temperature of 1,500° C. (equals 2,732° F.) he calculated the waste heat of various furnaces as follows:

	Waste heat.
Direct fired pot furnaces	70·0%
Tank furnaces, air only preheated, open-grate producers	39·5%
Tank furnaces, air only preheated, steam-blast producers	35·9%
Tank furnaces, air and gas preheated, open-grate producers	33·7%
Tank furnaces, air and gas preheated, steam-blast producers	15·7%

For other than melting furnaces operating at 1,000° C. (equals 1,832° F.):

	Waste heat.
Direct fired	43·2%
Air only regenerated, open-grate producers	24·3%
Air only regenerated, steam-blast producers	22·0%
Air and gas regenerated, open-grate producers	24·3%
Air and gas regenerated, steam-blast producers	15·2%

These figures confirm the results of actual practice that the higher the temperature attained the greater the economy of the regenerative furnace; but for low temperature furnaces almost as much economy is obtained from the use of simple recuperation and open grate producers as by double recuperation or by the use of steam-blast producers. Mr. Damour states that he considers about four-fifths of the above calculated figures to represent the actual efficiency in the various cases. In the same connection it is interesting to note his records of measurements of heat used and lost in various parts of a Siemens tank furnace of recent construction, with regeneration of both air and gas, and with steam-blast producers:

Used in melting part of furnace, including radiation of tank, cap, etc.	54·0%
Lost in gas producers	11·5%
Lost in regenerators	15·7%
Lost in stack	18·8%
	100·0%

The practical value of such measurements and calculations for the attainment of greater economy and increased efficiency, is obvious.

Considerable interest is being manifested in investigating the physical properties of glass, and especially in the relation of its chemical composition to its physical properties. Very extensive investigations have been made in almost all other branches of metallurgy, that have resulted in the establishment of well-defined standards. Unfortunately the glass industry does not as yet fully possess such standards, although it is to be hoped they may be soon developed. Much

* *Annals du Conservatoire des Arts et Metiers.*

has been done in this direction by Dr. C. Schott, at the works at Jena, Germany, who has recently published the results of years of investigation.* A few of his tests are noted as follows:

Seventy-two tests for tensile strength made on 17 different samples of glass of section from 0·0179 to 0·0298 sq. in. gave an average maximum load to produce rupture of 9,588 lb. per sq. in. The greatest load was 11,878 lb., the smallest 5,202 lb. The effect on tensile strength of various constituents in the order of their value is CaO, ZnO, SiO_2, P_2O_5, B_2O_3, BaO, Al_2O_3, As_2O_5, PbO, Na_2O, K_2O, MgO.

Seventy-seven tests for compressive strength made on the same 17 samples gave an average crushing load of 123,608 lb. per sq. in. The greatest load was 179,-794 lb., the smallest 86,198 lb. The effect on compressive strength of various constituents in the order of their value is SiO_2, MgO, Al_2O_3, As_2O_3, B_2O_3, P_2O_5, BaO, ZnO, Na_2O, PbO, CaO, K_2O.

Tests of 19 samples, including those already used, gave an average modulus of elasticity of 9,387,972 lb., the greatest being 11,339,532 lb., the smallest 6,930,-461 lb. The effect of the various constituents did not seem to be the same in all cases, the elasticity seeming to depend more upon certain combinations than on the presence of any certain substances.

It is worthy of note that these determinations show much higher values than are usually given. Kent† gives the tensile strength of glass from 4,200 to 6,000 lb., compressive strength from 13,130 to 39,876 lb., and modulus of elasticity, 8,000,000 lb.

Tests to determine specific heat made on 18 samples gave an average of 0·1747, the highest being 0·2415, the lowest 0·0817. The product of the specific heat and specific gravity is not constant.

Tests to determine the coefficient of expansion made on 30 samples gave a range of cubical expansion in terms of the coefficient equal $3a \cdot 10^7$, of from 110 to 337. The effect on expansion of various constituents in the order of their value is Na_2O, K_2O, CaO, Al_2O_3, BaO, PbO, As_2O_5, P_2O_5, ZnO, SiO_2, MgO, B_2O_3. The cubical expansion as given by Clark‡ ranges from 214 to 269 in terms of the same formula.

The glass industry should have a much better technology than now exists, and it can only be built up by the interchange of experiences of practical glass men through the media of technical journals and societies. Quoting from a most excellent address before the American Institute of Mining Engineers by its President, Dr. Douglas: "It may be inferred with justice, that the progress achieved in iron and steel making, and the delightful candor with which iron-masters discuss their trials and tribulations and explain the solution of their difficulties, are related, not accidentally, but intimately, as cause and effect."

* Jenaer Glas, by Dr. H. Hovestadt.

† "Mechanical Engineers' Pocket Book," p. 308. ‡ *Ibid.*, p. 460.

GOLD AND SILVER.

THE world's production of gold in 1900 was 12,381,454 fine oz. or $255,924,654, as against 15,071,141 oz., or $311,505,947 in 1899, showing a decrease of 2,689,687 oz., or $55,581,293. This unfavorable result was due to the small contribution made by the Transvaal mines, a few only of which were operated during the early months of the year.

The United States again occupies the first position as a producer, which it lost in 1898, while Australia is second and Canada third. Transvaal, which led all other countries in 1898, has fallen to the seventh place on the list, with an output below that of Mexico. But for the Boer war, this country would have easily maintained its position as the world's greatest gold producer. The output of the Rand mines under normal conditions, such as prevailed from 1896 to 1898, would have amounted in round numbers to $100,000,000 in 1899, and $120,000,000 in 1900. Deducting the Transvaal output from the grand totals for 1899 and 1900, the statistics show an increase in the other gold producing countries of $10,171,000. The largest gains were made by the United States, Canada, India, Rhodesia and Brazil, while in Australia and China there were important decreases.

PRODUCTION OF GOLD IN THE UNITED STATES.

State or Territory.	1897.		1898.		1899.		1900.	
	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)
Alaska	130,624	$2,700,000	136,430	$2,820,000	247,944	$5,125,000	364,385	$7,531,835
Arizona	130,624	2,700,000	116,110	2,400,000	124,577	2,575,000	131,834	2,725,000
California	725,689	15,000,000	740,203	15,300,000	730,527	15,100,000	757,136	15,650,000
Colorado	947,249	19,579,637	1,138,584	23,534,531	1,282,471	26,508,675	1,391,486	28,762,036
Idaho	96,759	2,000,000	99,178	2,050,000	84,664	1,750,000	100,000	2,067,000
Montana	217,534	4,496,431	253,890	5,247,913	233,147	4,819,157	249,153	5,150,000
Nevada	145,138	3,000,000	145,138	3,000,000	107,644	2,225,000	97,910	2,023,803
New Mexico	22,738	470,000	23,222	480,000	24,190	500,000	36,284	750,000
Oregon	65,534	1,354,593	58,862	1,216,669	62,893	1,300,000	79,342	1,640,000
South Dakota	256,410	5,300,000	276,730	5,720,000	282,944	5,848,464	320,513	6,625,000
Southern States (b)	12,082	249,737	12,731	263,153	8,466	175,000	11,127	230,000
Utah	89,305	1,845,938	114,777	2,372,442	166,909	3,450,000	200,290	4,140,000
Washington	21,754	449,664	29,028	600,000	32,656	675,000	38,703	800,000
Other States	3,136	64,795	3,760	77,722	2,164	44,725	3,145	65,000
Total domestic	2,864,576	$59,210,795	3,148,642	$65,082,430	3,391,196	$70,096,021	3,781,310	$78,159,674
Foreign	584,983	12,091,599	1,065,552	22,024,960	1,423,449	29,422,691	1,948,519	40,275,888
Grand total	3,449,559	71,302,394	4,214,194	87,107,390	4,814,645	99,518,712	5,729,829	118,435,562
Total domestic—kg	89,092		97,933		105,471		117,611	
Total foreign—kg	18,194		33,142		44,274		60,605	
Grand total—kg	107,286		131,075		149,745		178,216	

(a) 1 oz. gold = $20·67; 1 kg. = $664·60. (b) Virginia, South Carolina, North Carolina, Georgia, Alabama and Texas.

GOLD PRODUCTION OF THE WORLD.

Countries.	1898.			1899.			1900.		
	Fine Ounces.	Kilograms.	Value.	Fine Ounces.	Kilograms.	Value.	Fine Ounces.	Kilograms.	Value.
AMERICA, NORTH:									
United States	3,148,642	97,932·9	$65,082,430	3,391,196	105,471·0	$70,096,021	3,781,310	117,610·6	$78,159,674
Canada	662,796	20,613·9	13,700,000	1,018,371	31,674·6	21,049,730	1,350,593	42,007·8	27,916,752
Newfoundland	3,000	93·3	62,010	2,600	80·9	53,742	2,400	74·6	49.608
Mexico (*a*)	398,487	12,393·5	8,236,720	448,832	13,960·1	9,277,351	455,204	14,158·3	9,409,063
Central America	24,435	760·0	505,096	25,402	790·0	525,034	27,818	865·2	*e* 575,000
AMERICA, SOUTH:									
Argentina	6,661	207·0	137,700	3,628	112·8	*e* 75,000	3,628	112·8	*e* 75,000
Bolivia	16,617	517·0	343,500	7,256	225·6	*e* 125,000	7,256	225·6	*e* 150,000
Brazil	76,613	2,383·0	1,583,700	107,644	3,348·1	2,225,000	127,818	3,975·3	*e* 2,642,060
Chile (*b*)	60,000	1,866·2	1,240,000	46,110	1,434·1	*e* 953,100	43,541	1,354·2	*e* 900,000
Colombia	179,003	5,567·3	3,700,000	111,272	3,462·2	2,300,000	111,272	3,462·7	*e* 2,300,000
Ecuador	1,911	59·0	39,500	6,047	188·1	125,000	9,676	300·9	200,000
Guiana (British)	99,105	3,082·0	2,048,297	108,269	3,367·5	2,238,040	110,640	3,441·3	2,286,918
Guiana (Dutch)	27,532	856·0	568,898	26,972	838·9	557,532	25,239	785·0	521,690
Guiana (French)	79,547	2,474·0	1,644,260	80,072	2,490·5	1,655,088	68,353	2,126·0	1,412,857
Peru	31,572	982·0	652,593	41,636	1,295·0	860,616	41,636	*e* 1,295·0	860,616
Uruguay	2,411	75·0	49,845	1,961	61·0	40,540	1,961	61·0	40,540
Venezuela	46,169	1,436·0	954,365	49,191	1,530·0	1,016,888	49,191	1,530·0	1,016,888
EUROPE:									
Austria	2,299	71·5	47,520	1,854	57·7	38,312	1,854	*e* 57·7	38,312
Hungary	88,994	2,768·0	1,839,506	96,710	3,007·9	1,999,002	96,710	*e* 3,007·9	1,999,002
France	8,584	267·0	177,448	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*e Nil.*	*Nil.*
Germany (*d*)	3,569	111·0	73,771	3,588	111·6	74,169	3,588	*e* 111·6	74,169
Italy	6,041	187·9	124,867	3,643	113·3	75,301	3,643	*e* 113·3	75,301
Norway	74	2·3	1,539	74	2·3	1,539	74	*e* 2·3	1,539
Portugal	219	6·8	11,098	7	0·2	150	7	*e* 0·2	150
Russia	1,196,634	37,217·0	24,734,418	1,159,214	36,056·3	23,963,016	1,117,054	34,744·0	23,090,862
Spain	1,979	60·0	33,873	387	12·4	8,000	387	*e* 12·4	8,000
Sweden	4,048	125·9	83,672	3,414	106·2	70,580	3,414	*e* 106·2	70,580
Turkey	375	11·6	7,751	375	*e* 11·6	7,751	375	*e* 11·6	7,751
United Kingdom	306	9·0	6,321	2,845	88·5	58,810	6,047	188·1	125,000
AFRICA:									
Transvaal	3,777,009	117,470·3	78,070,761	3,529,826	109,782·6	72,961,501	348,760	10,846·9	7,208,869
Abyssinia	20,126	626·0	416,000	20,126	*e* 626·0	416,000	20,126	626·0	416,000
Rhodesia	20,981	652·5	433,682	54,241	1,687·0	1,127,170	79,354	2,468·0	1,640,251
Soudan	2,701	*c* 84·0	55,830	2,701	*e* 84·0	55,830	2,701	*e* 84·0	55,830
West Coast	34,845	1,083·7	720,248	33,978	1,005·7	702,327	36,285	1,128·5	*e* 750,000
Madagascar	3,151	*c* 98·0	65,110	11,060	*c* 344·0	228,622	11,060	*e* 344·0	228,622
ASIA:									
Borneo (British)	8,038	250·0	166,150	11,168	347 3	230,850	16,933	526·7	*e* 350,000
China	321,296	9,992·8	6,641,190	273,246	8,501·4	5,650,000	208,031	6,470·1	4,300,000
East Indies (Dutch)	5,691	177·0	117,623	7,234	225·0	149,527	26,609	827·3	550,000
India (British)	375,704	11,684·9	7,765,807	405,683	12,618·2	8,385,467	448,100	13,936·6	9,262,226
Japan	37,334	1,161·2	771,734	53,994	1,679·4	1,116,129	62,893	1,956·0	*e* 1,300,000
Korea	55,432	1,724·0	1,145,769	70,954	2,206·9	1,466,690	77,407	2,407·5	*e* 1,600,000
Malay Peninsula	25,000	777·5	516,750	16,459	512·0	340,200	16,449	511·6	*e* 340,000
AUSTRALASIA (*f*)	3,013,763	93,732·3	62,294,481	3,810,130	118,500·0	78,755,372	3,554,286	110,549·8	73,467,110
Unspecified (*g*)	21,771	677·1	*e* 450,000	21,771	677·1	*e* 450,000	21,771	677·1	*e* 450,000
Totals	13,900,465	432,327·4	287,327,833	15,071,141	468,695·0	$311,505,947	12,381,454	385,103·2	255,924,654

(*a*) Figures based on exports of ores, matte, etc., and coinage. (*b*) Computed from exports. (*c*) As reported by the *Statistique de l'Industrie Minerale*. (*d*) Production from domestic ores. (*e*) Estimated. (*f*) Includes six States and New Zealand. (*g*) Includes Servia, Persia, West Indies, Formosa, British New Guinea and Philippine Islands.

The silver production of the world increased from 177,836,582 Troy oz. in 1899 to 182,632,653 oz. in 1900, a gain of 4,796,071 oz. The United States continued to hold the first place as a producer; with Mexico second, and Germany, Australia and Bolivia following in the order mentioned. A large part of the output of the refineries in Germany is recovered from imported ores and bullion, and consequently should be credited to other countries as has been done in the table on the following page.

PRODUCTION OF SILVER IN THE UNITED STATES.

State or Territory.	1897.		1898.		1899.		1900.	
	Troy Ounces.	Commercial Value. (*a*)	Troy Ounces.	Commercial Value. (*a*)	Troy Ounces.	Commercial Value. (*a*)	Troy Ounces.	Commercial Value. (*a*)
Alaska	250,900	$149,475	150,000	$87,390	150,000	$89,370	200,000	$122,820
Arizona	1,332,292	796,577	2,250,000	1,310,850	2,000,000	1,191,600	1,750,000	1,074,675
California	757,300	452,790	650,000	378,690	600,000	357,480	1,170,902	719,051
Colorado	21,278,202	12,722,227	23,502,601	13,692,615	23,114,688	13,771,731	20,336,712	12,488,775
Idaho	6,000,000	3,587,400	6,284,744	3,661,492	4,800,000	2,859,840	6,100,000	3,746,010
Montana	16,807,346	10,049,112	14,818,662	8,633,352	16,850,755	10,039,680	17,300,000	10,623,930
Nevada	1,500,000	896,850	800,000	466,080	575,000	342,585	1,300,000	798,330
New Mexico	350,000	209,265	450,000	262,170	550,000	327,690	550,000	337,755
Oregon	84,802	50,703	128,326	74,763	140,000	83,412	150,000	92,115
South Dakota	500,000	298,950	325,000	189,345	350,000	208,530	210,000	128,961
Texas	600,000	358,740	500,000	291,300	450,000	268,110	525,000	322,403
Utah	6,689,754	3,999,804	6,570,256	3,827,773	7,183,107	4,279,695	9,569,183	5,876,435
Washington	242,781	145,159	275,000	160,215	300,000	178,740	300,000	184,230
Others	64,815	38,753	50,443	29,388	63,284	37,705	100,000	61,410
Totals	56,457,292	$33,755,815	56,755,032	$33,065,482	57,126,834	$34,036,168	59,561,797	$36,576,900

(*a*) The average value in 1897 was 59·79c. per oz.; 58·26c. in 1898; 59·58c. in 1899, and 61·41c. in 1900.

SILVER PRODUCTION OF THE WORLD.

Countries.	1899.			1900.		
	Troy Ounces.	Kilograms.	Commercial Value.	Troy Ounces.	Kilograms.	Commercial Value.
AMERICA, NORTH:						
United States	57,126,834	1,776,829·1	$34,036,168	59,561,797	1,852,564·4	$36,576,900
Canada	3,078,837	95,761·8	1,834,371	4,446,505	138,300·7	2,730,599
Mexico (*a*)	55,032,838	1,711,699·1	32,788,565	55,804,420	1,794,167·9	34,269,494
Central America	1,446,795	45,000·0	862,001	1,446,795	*e* 45,000·0	888,477
AMERICA, SOUTH:						
Argentina	383,561	11,930·0	228,526	383,561	*e* 11,930·0	235,545
Bolivia	10,432,685	324,490·4	6,215,784	10,432,685	*e* 324,490·4	6,406,712
Chile (*b*)	5,772,791	179,552·4	3,439,430	5,772,791	179,552·4	3,545,071
Colombia	3,521,563	109,531·0	2,098,147	2,800,000	87,089·0	1,719,480
Ecuador	81,000	251·9	4,826	81,000	*e* 251·9	49,742
Peru (*a*)	6,526,653	203,000·0	3,888,580	6,590,955	*e* 205,000·0	4,047,505
EUROPE:						
Austria	1,272,022	39,564·0	757,871	1,272,022	*e* 39,564·0	781,149
Hungary	675,750	21,018·0	402,612	675,750	*e* 21,018·0	414,978
France	466,189	14,500·0	273,755	466,189	*e* 14,500·0	286,287
Germany (*c*)	6,243,326	194,187·6	3,719,773	6,243,326	*e* 194,187·6	3,834,026
Greece	1,294,917	40,276·1	771,512	1,294,917	*e* 40,276·1	795,209
Italy	1,081,707	33,644·6	644,481	1,081,707	*e* 33,644·6	664,276
Norway	154,389	4,802·0	91,985	154,389	*e* 4,802·0	94,810
Russia	260,809	8,112·0	155,390	163,960	5,099·7	100,688
Servia	18,326	570·0	10,919	18,386	*e* 570·0	11,291
Spain	5,448,019	169,451·0	3,245,930	5,909,418	183,802·0	3,628,974
Sweden	73,626	2,290·0	43,968	73,626	*e* 2,290·0	45,214
Turkey	65,363	2,033·0	38,943	65,363	*e* 2,033·0	40,139
United Kingdom	191,927	5,969·5	106,770	191,927	5,965·5	106,770
ASIA:						
Dutch East Indies	1,286	40·0	766	1,447	*e* 45·0	887
Japan	1,810,375	56,308·5	1,078,622	1,810,375	*e* 56,308·5	1,111,751
Australasia	15,326,768	476,712·0	9,131,688	14,063,244	437,412·3	8,636,238
Other countries (*d*)	48,226	1,500·0	28,733	48,226	1,500·0	29,616
Totals	177,836,582	5,529,024·0	$105,900,116	182,632,653	5,681,363·0	$112,205,742

(*a*) Statistics compiled from exports and coinage. (*b*) Exports of silver in all forms. (*c*) Silver produced from domestic ores only. (*d*) The output is mostly from China and Persia. (*e*) Estimated. NOTE.—Unless specified to the contrary, the statistics have been taken from official sources or have been collected directly from the producers by THE MINERAL INDUSTRY.



THE WORLD'S PRODUCTION OF GOLD

During the period from 1875 to 1899, the world's annual production of gold increased from $115,576,598 (173,904 kg.) to $311,505,947 (468,695 kg.), a gain of more than 170%. In the 15 years following 1875, there was little change in the annual output, the totals ranging between the high mark of $123,513,916 (185,847 kg.) for 1878 and the low mark of $95,185,564 (144,727 kg.) for 1883. From 1890, when the production was $119,600,000 (181,256 kg.), the growth has been very rapid owing to a variety of causes, chief among which are the application of the cyanide and the chlorination processes in treating refractory ores, the development of the South African fields and the discovery of the new fields in Alaska.



THE WORLD'S PRODUCTION OF SILVER IN TROY OUNCES.

PRICES OF SILVER.

The average prices of silver in New York and London, as computed by *The Engineering and Mining Journal,* are shown in the subjoined table. The higher average in 1900 was due to the demand for coinage in the East and extensive use in the arts.

Month.	1898.		1899.		1900.		Month.	1898.		1899.		1900.	
	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.		London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.
January	26·29	56·77	27·42	59·36	27·30	59·30	August	27·48	59·54	27·62	60·00	28·13	61·14
February	25·89	56·07	27·44	59·42	27·49	59·76	September	28·05	60·68	27·15	58·89	28·85	62·63
March	25·47	54·90	27·48	59·64	27·59	59·81	October	27·90	60·42	26·70	57·98	29·58	63·83
April	25·95	56·02	27·65	60·19	27·41	59·59	November	27·93	60·60	27·02	58·67	27·66	64·04
May	26·31	56·98	28·15	61·23	27·56	59·96	December	27·45	59·42	27·21	58·99	29·68	64·14
June	27·09	58·61	27·77	60·43	27·81	60·42							
July	27·32	59·66	27·71	60·26	28·23	61·25	Year	26·76	58·20	27·44	59·58	28·17	61·41

NOTE.—The New York prices are per fine ounce; the London quotations are per standard ounce, which is ·925 fine.

Gold and Silver Mining in the United States.

Alaska.—The production of gold in this Territory during 1900 was 364,385 oz. ($7,531,835) against 247,944 oz. ($5,125,000) in 1899, the increase coming mainly from the Nome district. It is to be regretted that Congress has so far done nothing of material importance for the betterment of the mining laws for Alaska. One of the greatest faults in the existing laws is the permission to stake claims by proxy, which has resulted in the wholesale staking of everything in sight.

Nome District.—The past year was on the whole a disappointment. The productive claims of the beach were practically worked out during the winter months, as were also the Topkuk beach diggings. It is estimated that from 30,000 to 40,000 men, women and children, representing every trade and profession, made their way to Nome during the summer months. While owing to unfavorable weather but little work was done toward opening up new claims, speculative business ventures were grossly overdone, and Nome developed into a city several times too large to be supported by the district around. It is estimated that $5,000,000 has been invested here in beach mining outfits alone. During 1900 at least 1,600 sluicing plants were installed on the beach of Nome, but the results fell below expectations, as the yield of $1,500,000 from this source in 1899 had left the beach nearly exhausted. Twenty dredges, constructed to operate the beach sands, were all abandoned and but few of the efforts to work the sand below tide met with success. The bars at exceptionally low tide were profitably worked, for from these some gold may be obtained at slack tide, with a calm sea. In Nome and Koogrock districts, there are vast deposits of low-grade ore, too low to be worked by ordinary sluicing but which may be profitably worked by hydraulicking or dredging on a large scale. On Anvil and Dexter Creeks the best discoveries have been developed. The most recent and conspicuous trouble in the mining fields at Cape Nome has been the litigation caused by the Alaska Gold Mining Co., of Arizona. Mr. Alexander McKenzie, its representative at Nome, purchased many claims from alleged "jumpers" which threw the property into litigation, thus tying up much of the most productive property. A compromise was made on January 31, 1901, by which the title of his company was cleared to Nome mine property estimated to be worth $10,000,000. By the settlement all the rights to the Anvil and the Dexter Creeks mines are vested in the Pioneer Mining Co., together with the Discovery Claim, which has produced more than $1,000,000 worth of dust. It also has ended litigation in the suits for sums amounting to $430,000. Before August 1, 1900, the rush of people to return from Nome was nearly as great as that of their coming, and the sickness and destitution were such that some 4,000 people applied to the military authorities for food daily. The output from Nome in 1900, estimated at $4,000,000, is probably less than half the sum expended in the rush to these diggings last year. With the clearance of claim titles and the establishment of systematic mining, an increased yield of gold over the present year's product may reasonably be expected at Nome for several years to come.

Juneau and Other Districts.—In the Juneau district 1,254 stamps were in

operation in 1900, of which 880 were controlled by the Alaska-Treadwell Gold Mining Co., on Douglas Island, near Juneau. Five mills are equipped with the following number of stamps: The Treadwell, 240; the New Treadwell, 300; the Ready Bullion, 120; the Alaska-Mexican, 120, and "The 700," 100. The Alaska Treadwell Gold Mining Co. during the year ending May 31, 1900, stamped 557,960 tons of ore, which yielded $773,165 ($1·39 per ton) in free gold, and $380,202 ($0·68 per ton) in sulphurets, a total of $1,153,368 or $2·07 per ton. The sulphurets were shipped to the Tacoma Smelting Co. A reduction in the operating costs was made, the total being $0·8676 per ton, divided as follows: Mining, 49·86c.; milling and concentrating, 19·88c.; sulphuret expense, 14·23c.; San Francisco office expense, 1·11c.; London office expense, 0·24c.; Paris office expense, 0·05c.; consulting engineer expense, 0·19c.; legal expense at San Francisco, 0·23c.; dividend warrant expense, 0·15c.; bullion charges, 1·26c.; expense on construction account, 5·38c., making the total operating and construction costs, after deducting excess credit to general expense, 92·14c. per ton. The 240 stamp mill ran 312 days, averaging 3·01 tons per stamp each day. The 300 stamp mill ran 270 days, crushing 4·10 tons per stamp each day. The amount of ore in sight and available for the mill on May 15, 1900, was estimated at 4,131,640 tons.

On Six Mile and Canyon Creeks, Cook's Inlet, Mr. S. W. Wible has installed a complete hydraulic plant and will add another next season. A dozen hydraulic plants are under construction, or have been started, on the different creeks in the district. The estimated yield of gold from the Cook's Inlet region in 1900, was $100,000. A new discovery of gold in placer diggings was made last August in the Copper River, 500 miles from its mouth, on Slate Creek, a tributary of the Chistochina.

In the interior of Alaska, the Circle City, Jack Wade, Munock and Kyokuk districts have produced altogether about $1,000,000 in gold during the past year. Most of this gold is sold in Dawson. By the completion of the railroad from Skagway to the navigable waters of the Yukon the transportation of passengers and freight to Dawson is made reasonably sure and easy.

Arizona.—The year in Arizona has been one of unusual activity in the search for new mines, while the older ones have kept well at work. Many new and promising prospects have been opened, among which are already producing the Octave and the Penn in Yavapai County, and the King of Arizona in Yuma County. The Harqua Hala mines have resumed work under control of the original owner who bought them back from the English company to which he had sold them. The mines at Mammoth are still in operation, and many small mines are at work in the mining region around Prescott. Much prospecting is being done in the vicinity of Wickenburg and in the region immediately west of Congress, with many reports of rich strikes. A new company has bought the old Ventura mine, intending to resume operations there on a large scale. Placer mining is still carried on at various points when water is available, and numerous plans are afoot for increasing the yields through storing the flood waters in reservoirs. The cyanide process for the reduction of ores is applied at the Mammoth, King of Arizona, Vulture, Octave and Congress mines and at many other

points, on a smaller scale, on old tailing piles. Silver ores carrying gold are still shipped from the Tombstone district, and it is likely that the gold output of the Territory in the course of the next two years will be materially increased through the resumption of work there on a large scale. At the Congress mine a new 40-stamp concentrating mill has recently been placed, and the cyanide plant has been increased to a capacity of 300 tons per day. A considerable and increasing proportion of the gold product of the Territory is obtained as a by-product in the treatment of copper ores.

California.—(With the collaboration of A. E. Heighway and Toliesin Evans.) —There was a gradual and healthy increase in the production of gold during 1900, the total output amounting to $15,650,000, against $14,800,00 in the previous year. The product was derived mainly from the older mines, although a few new ones were opened in Siskiyou, Shasta and Trinity counties, a large portion of the ores from which found a ready market at Keswick, where quartz has been in demand for flux at the smelters. Besides the discovery of these new mines, the most important factors in the improved conditions have been the deeper exploration of the quartz veins and the application of dredging to river and beach mining. The success attained in the Kennedy mine of Amador County has shown the fallacy of the theory that California quartz ledges are not enduring as producers beyond moderate depths. This property located on the "Mother Lode" proved to be practically barren at the 800 ft. level and was virtually abandoned by the owners. A second effort to find ore in paying quantities was awarded after sinking the shaft below the 1,000-ft. level. As a further illustration, the Empire mine of Grass Valley, the oldest quartz mine in the State, was about to be closed some time ago as the working had reached the limit of the pumping and hoisting plant, and the value of the ore at the lower levels was not sufficient to warrant the expense of re-equipment. Exploration, however, on veins hitherto considered barren, revealed other pay chutes so rich that the company has decided to install new machinery and to carry the workings at least 1,000 ft. lower. At the present rate of production it is stated that the mine will last for many years. The development of dredging has been rapid and this method of mining is now being carried on in ten counties, Siskiyou, Shasta, Trinity, Yuba, Butte, Nevada, Calaveras, Placer, Sacramento and San Bernardino. The most important field is on the Feather River at Oroville, Butte County, where ten dredges were in operation during the year. The field extends on both sides of the river for 6 miles, and is 2 to 3 miles wide. Two dredges are at work on the Klamath River and its tributaries, two on Trinity River, one on the Stanislaus and one or more at the potholes of the Colorado. Several million dollars have been invested in mining ground and plant, and the yearly output of gold from this source may be estimated at $1,000,000. The cost of handling placer material by this method varies from 4 to 15c. per cubic yard. The Utica Group of mines in Calaveras County has demonstrated that profits can be earned by treating large quantities of low-grade ore, and similar results have been attained by other properties such as the Rawhide, Gwynn, Oneida and Eureka, where the cyanide process is used. The adoption wherever possible of electric power generated from mountain streams and reservoirs is an important factor

in reducing mining and milling costs. At the Golden Cross mine of San Diego, which may be regarded as a representative mine of southern California, the cost of mining, milling and cyaniding the tailings is stated to be $1·60 per ton, while the cost sheet of the Gwynn Mine, Calaveras County, a representative "Mother Lode" mine, for a month's operations covering an output of 7,000 tons ore, was $2·655 per ton. In the latter figure are included management, office and transportation expenses. . The Rose Gold Mining Co., Victor, San Bernardino County, gives the cost of mining, milling and cyaniding 33 tons of ore per shift of 11 hours, at $2·44 per ton. The cost of oil, fuel, potassium cyanide, lime and zinc and discharging vats was $1·19 per ton, while the mining expenses were $1·25 per ton. Past operations in the Kennedy mine, which is over 2,000 ft. deep, have averaged a little more than $4·50 per ton, but the costs have been reduced by recent improvements. Silver is recovered as a by-product in gold, lead and copper mining, but there are no mines which produce this metal alone. It is impossible to ascertain the actual output, but it is reported by the California State Mining Bureau at 1,170,902 oz. in 1900, against 854,000 oz. in 1899. Shasta and San Bernardino counties yield the largest amounts.

Colorado.—In gold output, Colorado stands first among the States, with a total production, in 1900, of 1,391,487 oz. ($28,762,036·29). The silver output for the year was 20,336,712 oz. which at $0·6141 per oz. gives a value of $12,488,-775. The large output of Cripple Creek and Leadville was assisted by the old district of Gilpin and many smaller mines. The Cripple Creek mines lead the State in productiveness of gold. There were in the past year many changes of ownership and consolidations in this district which, in most cases, have been favorable to the productiveness of the property affected. The yield of ore in the district was large and shipments regular throughout the year. The bulk of the milling ore was sent as usual to be treated by the chemical mills at Florence and Colorado City, and some was handled by the Atlas mill at Boulder. No new mills were built last year in the Cripple Creek district for, with improvements in shipping facilities, it has become more profitable to send the ore to the great valley mills where labor and fuel are cheaper than to reduce it at the mines. In anticipation of added demands from Cripple Creek new mills have been completed and old ones refitted both at Florence and at Boulder City. While Leadville had no boom during the past year the work went on steadily, shipments were regular and the total production of all kinds of ore exceeded by $4,000,000 in value the yield in 1899. In the Gold Belt much new work was started with good results. The same was true of the claims forming the rim of the Gold Belt on which more work was done than in several previous years. The facilities at the camp for reducing the ores were increased, by extensive enlargements and improvements in the Arkansas Valley smelter. In Gilpin County, while the yield for the past year fell short of the usual mark, the 18 local mills with their 668 stamps, and the Rocky Mountain concentrator of 40 tons capacity, were kept running overtime, and 58,689 tons of smelting and crude ores, concentrates and tailings were shipped from Black Hawk station to the mills and smelters at Denver and other places. Now that the policy to be followed in the handling of the Independence mine at Cripple Creek has been determined there is hope for

profitable returns from the property. The report of the distinguished mine expert, Mr. John Hays Hammond, appointed by the English stockholders to investigate the mine after the discovery last year that the property had been overestimated, stated that "the available ore, so far as present development extends, does not exceed 120,000 tons, with a gross value of $2,300,000, which will give a net yield of $1,000,000 for dividends." Mr. Hammond has been entrusted by the company with full authority to prosecute needed development of the mine, it being agreed that it shall pay in 1901 a dividend of $488,000, or 10% on the capital stock, the remainder of the year's profits to be applied to developing the mine. Under his direction the levels are now being lowered from 1,000 to 1,500 ft. in hope of the good results that have followed deep working in similar properties in the same district. There can be little doubt that the Independence is a good mine and can still be successfully worked. While the doubt and disappointment attending its acquirement by the Venture Co., of London, may check for a time the flotation of other Cripple Creek mines, there is every reason for the fullest confidence in the district and for the belief that it will be a large producer for many years to come.

The gold and silver outputs by counties are given as follows by Hon. Harry A. Lee in his report of the previous metal production during 1900:

County.	Gold Value.	Silver Value.	County.	Gold Value.	Silver Value.
Boulder.....	$607,015·89	$55,469·80	Pitkin (Aspen).....	$13,456·17	$2,529,549·14
Clear Creek.....	465,446·06	834,035·62	San Juan.....	757,204·11	418,396·77
Gilpin.....	1,655,501·14	145,173·24	San Miguel.....	1,827,352·02	698,042·56
Lake (Leadville)...	2,529,511·92	4,278,606·03	Teller (Cripple C'k)	18,147,681·24	49,614·37
Mineral (Creede)...	209,287·10	1,400,171·34			
Ouray	1,437,908·55	1,219,152·46	Total.....	$28,762,036.29	$12,488,774·84

Georgia.—There has been a revival in gold mining, particularly in Lumpkin and Cherokee counties, and capital to the extent of more than $1,000,000 was invested during 1900 to develop the ore deposits. Among the more important properties is the old Cherokee mine, which has recently been reopened. Throughout the State there are outcrops of veins of auriferous pyrites of good value and with the application of proper mining and concentrating methods profitable results will be obtained. The largest gold milling plant in the Dahlonega gold belt is the 120-stamp chlorination mill completed in May, 1900, by the Dahlonega Consolidated Gold Mining Co., which has acquired 7,000 acres of mineral land adjacent to Dahlonega. The mill and equipment, costing $500,000, is situated on the Yahoola River. The buildings comprise a stamp mill, 300×100 ft., a chlorination plant 128×128 ft., and necessary storehouses, shops, etc. The mill is equipped with 48 Frue vanners and has a capacity of 600 tons daily. The ore is expected to average $7 per ton. The mill is run by water power and the chlorination plant can treat from 30 to 50 tons of concentrates daily. For a given quantity of ore the entire time of treatment is 36 hours. At Dahlonega the Crown Mountain Gold Mining & Milling Co. is building a large mill and the Standard Gold Mining Co. is erecting a 120-stamp mill with concentrating tables, on the Yahoola River. Both of these companies will use chlorination plants. Each mill will have a capacity of from 500 to 600 tons of ore per day,

and will be run by electricity generated at water falls 7 and 10 miles distant. Several other companies are operating small mills near Dahlonega. The aggregate capital stock of the gold mining companies operating and preparing to operate in this district is over $15,000,000.

At the Haile gold mines the following conditions in milling auriferous pyrites are recorded: Number of stamps 60, stamp weight 750 lb., drop per minute 90, stamp capacity 2 to 2·5 tons per 24 hours, quicksilver consumption 0·35 oz. per ton of ore crushed, wear of shoes and dies 0·5 lb. per ton, fineness of gold 880. The tailings from the mill are concentrated on 26 tables of the Embrey and Wilfley type and various qualities of concentrates are produced which average 90% pyrite and from $25 to $35 gold per ton.

Idaho.—The year's record shows an increase in the production of gold, the figures being $2,067,000, as compared with $1,750,000 in 1899. The output of silver increased from 4,242,000 oz. in 1899 to 6,100,000 oz. in 1900. This increase was due to the activity among the lead-silver mines, operations being stimulated by the high prices of lead. The De Lamar Mining Co., which operates the most important gold mine in this State, produced bullion to the value of $529,833 during the fiscal year ending March 31, 1900, an increase of $80,286 over the amount of the preceding year. A new tailings plant with a capacity of 150 tons per day was installed, and a refinery erected for treating the cyanides, the cost of the improvements being about $32,000. Work on the mill tunnel was started July 5, 1899, and during 209 working days it was advanced at an average rate of 12·95 ft. per day, which under the conditions is a remarkable record. The average cost per foot was $12·55. No discoveries of ore were made, and the ore reserves were reduced to a few thousand tons. The total cost of operation was $6·6472 per dry ton, a reduction of $1·22 below that of the previous year. The cost was divided as follows: General mining cost, including labor, supplies and its proportion of management expense, $3·5785 per ton; mining and marketing the shipping ore, $0·0547; milling, including labor, supplies and repairs and its proportion of management expenses, $2·2511; other expenses, including taxes, insurance, express charges on cyanide and bullion, etc., $0·2313. The cost of prospecting in 1899 was $1·6361 per ton. Analysis of the milling cost shows that the total, $2·2511 per dry ton, was divided into labor, $1·0144 and supplies, $1·2253. The latter, including chemicals, 72·44c. per ton; lubricants, 0·22c.; fuel, 20·56c.; blacksmith's coal, 0·44c.; belting, 0·82c.; illuminants, 0·21c.; lumber, 0·83c.; pipe and fittings, 0·22c.; tools, 0·43c.; assay office proportion, 0·48c.; refinery proportion, 3·5c.; freight and expressage, 12·42c.; legal expenses, 1·03c.; office and incidentals, 2·19c.; other supplies, 5·47c.; total, $1·2367. At Wagontown, some 2 miles below the De Lamar mine, a cyanide plant has been built to treat the old mill tailings, which are said to assay about $6 per ton. In the Cœur d'Alêne district, the Helena-Frisco mine was consolidated with the Black Bear and Milwaukee, and the Empire State-Idaho Mining and Development Co. took over the Buffalo Hump. The silver output of the district is estimated at 4,500,000 oz., against the reported production of 2,682,135 oz. in 1899. A large part of the gold output of Idaho comes from dredging and placer workings on Snake River. There were five dredges in operation in the latter part of 1900

and a successful future for this industry seems assured, although its history shows numerous failures. The principal difficulties in working the deposits, according to F. Powell are the limitation of the values to a few inches of surface gravel, necessitating the handling of a large amount of barren material, and the fineness of the gold, which is associated with magnetic iron sand in the form of flat or cup-shaped scales and fine grains, which run about 1,000 colors to the cent.

Montana.—The gold production of Montana in 1900 amounted to 249,153 oz. ($5,150,000) against 233,127 oz. ($4,819,157) in 1899, and the silver production to 17,300,000 oz. ($10,623,930) against 16,850,755 oz. ($10,039,680), giving a total increase in gold and silver values of $915,093. The successful treatment of low grade ores by the cyanide process has called for considerable activity, particularly in Fergus County. Among the new plants that have been completed or nearly so are the 140-ton mill of the Great Northern Mining & Development Co. at Gilt Edge; the 200-ton mill near the New Year mines; the 150-ton mill at Whiskey Gulch, south of Gilt Edge; the 100-ton mill in the Moccasin Mountains, 20 miles from Gilt Edge. By the spring of 1901 the mills in Fergus County will probably be treating 800 tons of ore daily. The deepest working of any of the mines in this county does not exceed 400 ft., so that the unoxidized ores have not as yet been developed in sufficient quantity to pay for the erection of roasting furnaces for preliminary treatment. The Montana Mining Co., according to the directors' report for the half year ending June 30, 1900, stamped 26,470 tons of ore. The mining and milling operation realized a profit of $46,599. The average cost per ton for mining and milling was $4·10 as compared with $4·83 for the previous six months. The dam-tailings plant was operated two months and twenty days treating 33,168 dry tons of tailings at a profit of $60,161·15 or $1·82 per ton. The average cost per ton for separating was: Treatment and transport, $1·17; redemption charge, $0·35; giving a total of $1·52, against $1·75 for the corresponding time in 1899. The development of the mine consisted of 3,464 ft. shafts, drifts and cross-cuts, uprises and winzes constructed at a cost of $52,931·04, or $2 per ton of ore milled. This high cost was due to the small tonnage of ore obtained. While sufficient ore was extracted to keep the 60-stamp mill in operation, the work on the whole was reported to be disappointing.

Nevada.—The latest attempt to revive mining in the Comstock Lode has been the introduction of electric power. Work was begun upon the electric power plant by the Truckee River General Electric Co. in the latter part of 1899, and the completion of the project was formally celebrated in October, 1900. Power for electrical generation is supplied by means of a big dam across the Truckee River at Floriston. The main line of the power plant from Floriston to Virginia City is 33 miles in length. On the Comstock the electric power is distributed to the mines from the sub-station, which supplies the Union and Sierra Nevada shafts, the Yellow Jacket and Beleton shafts and a branch line which connects with the Gould and Curry mill and other plants off the main route. Eventually the distribution line will be extended southward to Silver City. In anticipation of this cheap power the Gould & Curry Co. built a mill for treating its

low-grade ores, having a daily capacity of 100 tons of ore, and it was ready to set going at the completion of its electric plant to supply the motive force.

Oregon.—The gold mining industry presented no striking features during the past year. While placer mining has yielded the greater part of the output the quartz mines near Baker City were actively worked.

South Dakota.—During the year 1900 there was considerable activity in the construction of cyanide plants, the following having been erected: The Homestake at Lead, the Golden Gate at Deadwood, the Shawmut, the Portland and the South Dakota near Central, the Wasp No. 2 on Yellow Creek, the Deadwood and Detroit at Anne Creek, the Cleopatra on Squaw Creek, the Spearfish and the Allen-Small near Ragged Top, the Golden Crown near Highland Hoist, and the Clevenger at Rapid City. The construction of the plants indicates a great advancement in the treatment of low grade refractory ores formerly considered of little or no value. The Homestake plant is much the largest of the twelve; it has a capacity of 1,200 tons daily, and was built at a cost of $300,000. The plant will classify and treat tailings containing about $1·40 gold per ton. The Clevenger plant was erected for the purpose of treating the old tailings from the Rapid City chlorination plant near which the cyanide plant is situated. The operations although carried on in a small way were quite successful and will be continued. Similar efforts to rework the far greater quantities of Homestake tailings are being made. In addition to completing the large cyanide plant, the Homestake Co. has installed a million-dollar water system to supply water from Spearfish Creek. As a result various portions of the company's mines hitherto idle for lack of water to run the stamp mills are now being worked, and all of its mills are running full time. During the year ending June 30, 1900, the Homestake Mining Co. produced $3,583,726 mill bullion, or $4·02 per ton of ore. The total bullion account was made up of the following items: Mill bullion, $3,583,726; concentrates, net proceeds, $75,056; siliceous ores, net proceeds, $10,342; exchange, $174; total, $3,669,298. The total expenses were $3,014,647 and the net profits $830,084. Dividends amounting to $1,175,000 were paid during the year. The five mills in operation treated 891,585 tons of ore at an average cost of $0·80 per ton. By consolidation the Highland Mines, the Black Hills & Fort Pierre Railroad and the Black Hills Canal & Water Co. were acquired, while a considerable area of adjoining ground was added to the property by purchase. Outside the Homestake belt extensive and profitable operations were continued in the siliceous district, the various cyanide plants aiding in the increased activity. During the year direct railroad connection was made between Deadwood and Denver, Colorado, a connection which has long been desired by mining men and which will doubtless be of much benefit to the Black Hills region. According to H. M. Chase in a paper read before the American Institute of Mining Engineers, February, 1900, the cost of smelting ranges from $4·75 to $5·75 per ton, while that of chlorination amounts to $3 or $3·50 per ton. By the use of water power in place of steam a reduction of about 50c. per ton in the cost of treatment by the cyanide or chlorination processes could be made.

Utah.—There was a marked increase in the production of gold during 1900

as compared with 1899, the statistics being 260,290 oz. ($4,140,000) against 169,631 oz. ($3,506,582) for the respective years. The production was mainly from ores treated by smelters as, apart from the Mercur mines, there are very few direct gold producers in the State. The Utah branch of the American Smelting & Refining Co. produced during 1900, 41,332 oz. gold, 4,613,319 oz. silver, 47,958,928 lb. lead and 5,647,363 lb. copper. The Ontario Silver Mining Co. produced 10,247 tons of ore during 1899, which sold for $288,090·97. In addition, its mill product from tailings amounted to $76,225·84. The total expenses of operation were $172,016·64, which with the costs of tailings treatment leaves a profit for the year of $130,667·12, against a loss of $20,443 in 1898. The company repaired the Ontario mill with a view of again reducing the ore at the mines as soon as the contracts with the smelting combine expired.

The Daly-West Mining Co. shipped 16,000 tons of crude ore, and 10,116 tons of concentrates in 1900, for which the sum of $962,501 was received. Out of the net income, which amounted to $631,243, the amount of $487,500 was distributed in dividends, $24,972 expended in improvements, and $118,770 added to the surplus. The total metal contents of the ore as determined from assay, were: Copper, 597 short tons; lead, 6,587 short tons; gold, 1,310·7 oz.; silver, 1,388,755 oz.; zinc, 5,197 short tons.

No new producing camps made their appearance in 1900, though Gold Mountain, in Piute County, will shortly contribute to the gold production. The Annie Laurie mine has a large amount of ore in reserve which is stated to carry from $10 to $20 gold per ton. A modern 200-ton mill is under construction. The treatment scheme is cyaniding, followed by amalgamation.

Washington.—Toward the end of the year the new 200-ton mill of the Republic Exploration & Cyanide Co., an offshoot of the Republic Consolidated Gold Mining Co., was completed and 150 tons of ore were treated daily. The ore, crushed by rolls and ball mills to 60-mesh, is roasted for eight hours in straight-line roasting furnaces, of which there are three, and subsequently transported by rail to the cyanide tanks for a treatment lasting from six to eight days. The present equipment consists of 16 tanks, each of 110-ton capacity. Powdered zinc is used to precipitate the gold and silver from the cyanide solutions, the product being acid refined and melted into bars. The 75-ton custom mill, including two chlorination barrels of the Republic Reduction Co., was completed, but owing to insufficient crushing capacity extra machines were required, the delayed delivery of which handicapped the output. Early in 1901 the following rates for ore treatment were announced by Mr. Jackling, the superintendent of the Republic mill: For ores containing 0·6 oz. gold or less, $4·75 per ton; for ores carrying from 0·6 oz. to 1·25 oz. of gold, a sliding scale for each additional 0·25 oz., reaching $7·50 per ton; for ores of 1 oz. gold content or more, 90% of assay value is paid and on ores running less than 1 oz. 85% is paid. Silver is paid for at market quotations to the extent of 50% of the assay value of the ore. In addition to milling charges a sampling rate of 75c. per ton is levied. Considerable objection was raised by the Republic mine owners to the rate offered for silver. First-class ore from this district is shipped to the smelter at Great Forks, B. C., and the proposed railroad to give direct connection between these places will result in great benefit to the district.

Gold and Silver Mining in Foreign Countries.

North America.—*Canada.*—The production of gold in Canada in 1900 was $27,916,752, which places that dominion third in the list of gold producers. Four-fifths of the output came from the Yukon territory. British Columbia showed a fair increase, the exploitation of the Atlin district having turned the decline of placer mining into an increase. According to Wm. T. Robertson, Provincial Mineralogist of British Columbia, the production in 1900 was divided as follows: Placer gold, $1,278,724; lode gold, $3,453,381; a total of $4,732,105, against $4,202,473 in 1899. The Ontario mines yielded last year $297,861 in gold, a slight decrease from 1899, while in Nova Scotia the production was $577,581, a slight increase over the preceding year.

British Columbia.—Development work has been carried on in the Atlin district during 1900, in spite of local legislation which hindered progress. A five-stamp mill was operated to test a group of quartz claims, but little has been reported of its workings, as the property is in litigation. The Cariboo Consolidated Hydraulic Mining Co., Ltd., working on the Quesnel River, during 1900, produced gold to the value of $300,000 (unofficial) at a cost of $100,000. The total holdings of the company aggregate 2,584 acres of mining land, and it is estimated that 500,000,000 cu. yd. of auriferous gravel are available for future operations. The average gold tenor is 20c. per cu. yd. The mine equipment embraces four lines of 31-in. and 22-in. steel pipes, 6,000 ft. in length; six No. 3 hydraulic Giants, from 6 to 10 in. diameter, and 2,884 ft. of sluices 7 ft. wide and 4 ft. deep. A complete furnace plant for distilling amalgam is also included.

The 10-stamp mill at Ben d'Or, Lillooet district, crushed 5,020 tons of ore, saving 3,671 oz. gold at a mining and milling cost of $5·13 per ton.

The labor troubles in the Slocan district were satisfactorily adjusted during 1900, and the ore shipments exceeded the production in 1899, which amounted to $1,740,732. A large quantity of this output was shipped to the Trail smelter. About the only items of general interest that were presented in the past year in the Slocan district were the milling changes and the introduction of the cyanide process at the Athabasca mine for the treatment of battery tailings. The Slocan district is fast becoming a milling one, whereas formerly it produced ore that was shipped as mined or merely hand sorted. The Payne mine which still leads as a producer is fortunate in being the only well developed property that has so far carried all its values in clean ore, practically no concentrating material being produced. A number of innovations have been introduced at several of the milling plants, but are yet in the experimental stage. With the high-grade ore of the Slocan region, where the silver values are not all associated with the galena, but occur also in gray copper, blende and other silver minerals, the heaviest milling losses have naturally been in the fine material. The coarse concentration with Hartz jigs has usually given a very satisfactory result, but round tables have proved a failure in handling high-grade slimes and have generally been replaced by Wilfley tables which have given greatly improved results. The high ratio of silver to lead, *i.e.*, 2·5 oz. (minimum) silver per unit of lead

calls for very high efficiency in concentration, a condition of affairs that is strongly in contrast with the Cœur d'Alene and other low-grade camps where tonnage treated is to a certain degree more important commercially than high efficiency of concentration. The result from this has been that within the last two years in the Whitewater and other well managed mills the efficiency of the lead concentration has reached a point where it will compare most favorably with that of any lead district in the West. The silver efficiency is naturally variable and depends upon the mode of occurrence of the silver and the duty and working of the machines. The Athabasca plant operated a 10-stamp mill and the ore averaged $30 per ton. In June, 1900, however, the actual recovery was $59, with an efficiency of 80%, which shows an ore value of more than $73·75. The tailings from the plates are treated in vanners and afford a sulphuret concentrate of about $40 per ton value and tailings carrying from $6 to $10 per ton. These tailings are to be treated in a 30-ton cyanide plant, which will consist of five leaching vats 18 ft. in diameter. The treatment will last from 84 to 96 hours, and the cyanide solution will be of 0·3% strength. Zinc precipitation also is to be used. This will be the first cyanide plant in the district and it is anticipated that eventually concentrates also will be treated. The Ymir mine has opened up a vein of 600 ft. and a two-years' ore supply for 80 stamps is said to be in sight. This mill is now operating 80 stamps, and is one of the largest in the dominion. The daily tonnage is about 200 tons of $10 ore. A 12-ton experimental cyanide plant at the mine is in contemplation, and should it be successful, a larger installation will probably be erected.

The Le Roi Mining Co., Ltd., during the first six months of 1900, produced 51,336 tons of ore having a gross value of $738,251. The mine was shut down for more than two months owing to labor troubles, but by carrying out improvements and reorganizing the working forces and staff, the average daily output was nearly doubled. Additions to the smelting works at Northport, Wash., are in course of construction which will bring its capacity up to 1,250 tons per day. The gradual reduction of smelting charges has lead to an increased tonnage of lower grade ores that can be profitably treated. The appended table gives the production, metallic contents and values of ores produced from 1894 to 1900.

OUTPUT OF TRAIL CREEK MINES FROM 1894 TO 1900.

Years.	Tons of Ore.	Gold. Oz.	Value.	Silver. Oz.	Value.	Copper. Lb.	Value.	Total Value.
1894.....	1,856	3,723	$59,568	5,357	$3.214·20	106,229	$12,738·64	$75,520·64
1895.....	19,693	31,497	602,957	46,702	27,021·20	840,429	72,385·80	702,359·00
1896.....	38,075	55,275	1,104,500	89,285	50,830·00	1,580,635	79,030·00	1,243,360·00
1897.....	68,804	97,024	1,940,480	110,068	65,821·00	1,819,586	90,079·00	2,007,280·00
1898.....	111,282	87,343	1,746,861	170,304	94,539·00	5,232,011	629,411·00	2,470,811·00
1899.....	180,300	101,500	1,928,000	272,300	169,000·00	7,785,000	1,114,400·00	3,211,400·00
1900.....	217,636	111,625	2,306,173	167,378	97,648·00	2,071,865	335,435·00	2,739,256·00

Dawson.—The production of gold in the Yukon region during 1900 is given as $16,000,000. The greater output last year was due to the introduction of thawing machines, and hoisting and scraping machinery for raising the pay dirt from the shafts and for removing the muck from the top of the pay streak. The Canadian Government recently reduced the royalty charge on gold recovered

in the Yukon territory from 10% to 5%, a movement that will aid materially in the development of mining in that section. According to S. C. Dunham the only important hydraulic work on a large scale so far undertaken is on Australian Creek, a tributary of the Indian River, where preparations were made by an English-French syndicate for extensive operations, the necessary machinery, supplies, etc., having been shipped on by pack train. The problem of dredging the river beds is still unsolved and no attempts have been made in this direction. Steam thawing machines have been generally adopted in the winter diggings and a saving of 75% in the cost of fuel has resulted from their use which makes it possible to run shallow drifts, thus avoiding the expense of timbering so often necessary under the old method of burning. The mining industry and all ordinary business and commercial enterprises have become firmly established on a solid basis. It is estimated that at the present rate of production, it will take 10 years to exhaust the gold deposits now known to exist in the creeks and benches, and during this time the district will support a population of 15,000 to 20,000. An important factor in this estimate and one that has particular bearing on placer mining is the occurrence of gold on the hillsides far above the beds of the creeks. The distribution of gold throughout the Yukon basin and northern Alaska is beyond doubt much more general than was formerly supposed. The Discoverers Financial Corporation and the Universal Corporation, of London, intend to dredge the Saskatchewan River for gold during 1900. The auriferous gravel averages 7 ft. in depth, although at places it occurs to a depth of 25 ft. The dredges to be used are of the New Zealand type, each costing $25,000. From numerous tests it has been found that the gravel will yield an average of 25c. per cu. yd., and can be handled for 2c. per cu. yd. It is estimated that 3,000 yd. can be handled daily.

Nova Scotia.—The production of gold in Nova Scotia for the fiscal year ending September 30, 1900, amounted to 30,399 oz., against 27,772 oz. in the previous year. In the Renfrew district the Jubilee mine extracted 1,000 cu. ft. of rock that contained gold to the value of $30,000, and the Thompson mine was reported to have produced $71,000 gold during the first six months of 1900; one lot of ore, 110 tons, yielded 2,700 oz. The Brookfield Mining Co. has erected a chlorination plant at its mine and the results have been most satisfactory. Two 60-stamp mills now are operating in the province, while two additional ones of 100-stamps each have been contracted for.

Ontario.—The production of gold in the province during 1900 was valued at $297,861, a slight increase above the production in 1899. In the Deloro district, the Canadian Goldfields, Ltd., has increased its mill to 20 stamps and has doubled its arsenic plant, and the Cordova Co. has erected a 30-stamp mill near Marmora. The Sophia mine in Madoc supplied the 10-stamp mill erected last summer with free-milling ore of low grade. The Atlas Arsenic Co. will erect a Brown horseshoe furnace early in 1901, which will treat from 12 to 15 tons daily. Since March, 1900, the company has operated a 10-stamp mill at Five Acres, treating the mispickel ores by amalgamation, with a reported recovery of 82%. It also worked the Atlas mispickel mine near Malone, 6 miles north of

Deloro, where the vein averages 5 ft. width and yields nearly 20% pyrites. The ore assays average $8 in gold per ton.

In the Manitou-Wabigoon district considerable activity in mining has been shown, but the whole region is still practically a virgin field. The ore is free milling and it assays $15 per ton in gold, from 80 to 90% of which is saved by amalgamation, while from 10 to 20% is found associated with iron pyrites; the cost of treating the pyrite, however, is comparatively small, the total cost of treatment being $4 per ton. The quartz occurs in lenticular and also in true fissure veins, the former being bedded in walls of green chloritic and hornblende schist, and the latter in walls of eruptive granite or gneiss. The Sultana, the principal mine in the Lake of the Woods district, is profitably operating 30 stamps and a chlorination plant. The largest mills in the Rainy Lake and Seine River district are the Olive (25 stamps), the Alice A. (50 stamps), and the Hammond Reed (40 stamps). This latter mine is of quartziferous rock, and has a length of about 3 miles and a width of nearly 500 ft. The ore averages about $17 per ton in free gold, besides concentrates, while the cost of working and treating the same is estimated to be only $1·50 per ton.

Mexico.—The output of gold in 1900 was 455,204 oz., valued at $9,409,067 or about the same as in the previous year. There has been great activity in the exploration and development of gold mining properties, which doubtless will be reflected in the future returns, although having no appreciable effect on the present production. Some of the old mines which have been closed down for a number of years were unwatered and repaired, and operations will be carried on at greater depths. In the Guanajuato district the Sirene, Valcencia and Veta Madre mines were taken over by American and German capitalists, while the Silveragoa mine in the State of Sinaloa, upon which work was begun soon after the Spanish conquest and continued without interruption for 125 years, was also sold to an American company. It is stated that the Guggenheim Smelting Co. and the Consolidated Kansas City Smelting & Refining Co. have become largely interested in the Santa Barbara mining district, the latter having purchased over 100 claims, including the Alfareria, San Gertrudis, Rosario and Remedios. The largest transaction reported was the sale of the Escuadra property near Oactlan, State of Oaxaca, to New York parties for $3,500,000. Placer deposits were discovered along the Conchos River 80 miles from Chihuahua and many claims were located around San Domingo. At the beginning of the year the number of mining properties for which titles had been granted and were still in force was, of gold, 828; gold and silver, 1,675, gold and copper, 54, silver and copper, 4,024; silver and lead, 1,035, silver and iron, 42; silver and magnesite, 2. The report of the Grand Central Mining Co., Ltd., for the year ending August 31, 1900, shows net profits of £47,348, out of which £16,369 was spent on improvements and £26,225 or 2s. per share, paid in dividends, leaving a balance with that carried forward from the preceding year of £36,113. The reduction plant for the treatment of tailings was put in operation and during the month of September, 1900, the recovery was $37,582, at a cost of $21,436. Exploratory work was delayed by the lack of suitable apparatus for ventilation, which brought about a reduction of the ore reserves to 42,000 tons. The pro-

duction of silver in Mexico increased from 55,032,838 oz., in 1899 to 57,684,429 oz. in 1900. About one-fourth of the output of silver is deposited at the mints for coinage, while the remainder is exported, mostly to the United States, in the form of ores, sulphides, base bullion and in copper matte.

Newfoundland.—The gold production from Newfoundland in 1900 amounted to 2,400 oz. ($49,608) and was derived from 32,000 tons of copper ore averaging 0·06 (?) oz. gold per ton, which were shipped from Tilt Cove to Swansea, by the Cape Copper Co., Ltd. A deposit of auriferous sulphide in quartz containing 0·4 oz. gold per ton, has been reported at White Bay, but the property has not yet been worked. In past years unsuccessful attempts have been made to mine gold, at Brigus on Conception Bay and at Mings, on Notre Dame Bay. During 1900 several promising claims were taken out at Rose Blanche on the west coast of Bell Island, the largest being held by a company in St. Johns; 60 tons of ore have been shipped to different parts of Canada and the United States for a final mill test, and if satisfactory a 100-stamp mill will be erected. N. M. Howitt, of London, England, estimated the cost of mining, milling and working this ore body at from 40 to 50c. per ton. Labor is very cheap and abundant water power can be utilized.

CENTRAL AMERICA.—*Costa Rica.*—The principal mines in operation during 1899 were the La Tres Amigos, La Trinidad, Minas Monte Aguacate, Bella Vista and Montezuma (Thayer Mining and Milling Co.) and La Union (Costa Rica Union Mining Co.). Of these the Bella Vista and the Tres Amigos mines are the most important. The former is operating 20 stamps, 850 lb. each, and treats ore running from $5 to $200 in gold and silver values. The power is supplied by water and amounts to 40 H.P. They also have a cyanide plant of 30 tons daily capacity. The Tres Amigos is operating 10 stamps on ore containing up to 3·75 oz. gold, and recently a loan has been secured for the erection of a 30-ton cyanide plant. No exact statement of the product of the mines has been made, owing to the fact that bullion is shipped in a majority of cases without the knowledge of the Bureau of Statistics. The export of bullion is entirely unrestricted. The value of the annual export of gold in bars is reported to amount to $400,000.

Nicaragua.—The mining region as yet has been scarcely explored. The gold mines only are worked at present. The Nicaraguan mining code, based on the old Spanish law, is very liberal in its provisions. All machinery is admitted free of duty and no local tax is imposed on the mines. Foreigners can obtain concessions to exploit mines under the same conditions as the natives.

SOUTH AMERICA.—*Argentina.*—A discovery of rich auriferous sands has been reported at Neuquen. The deposit embraces the Pulmary Creek region and it is being worked profitably by the Chileans and Indians. Mining operations were resumed in Santa Catalina district, ore being extracted from the Jujuy, La Ventura, Cruz del Sur and La Perdida mines. The ore averages about 4 oz. per ton, with a high limit of 6 oz., and occurs in wide veins. It is freighted to Timan Cruz on burros at a cost of 50c. per ton, where the gold is extracted by milling and amalgamation. The mining industry in the northwestern provinces is being developed by a Belgian syndicate. In Rioja, near Famatina, a lead

and silver mining property has been taken up and the company at Nonogasta reports a very successful year's work.

H. D. Hoskold, Inspector General of Mines in the Argentine Republic, describes the geological features of the metalliferous regions.* The Cerro of the Capillitas, which is part of the great Cerro of Aconquija, trends N.E. It is mainly composed of gneiss granite, porphyry and trachytic rock containing masses of eruptive rock of conical form that rise close to the mines and are visible at a great distance. Numerous mines are included that are interlaced mostly in a granite formation underlying the trachytic rocks and containing ores of copper, silver and gold. The metalliferous zone consists of porphyry and gneiss through which the veins pass without changing their physical characteristics. The geological formation indicates that the ore is in true fissure veins, and suggests great possibilities for value in precious metal at depths entering the sulphide zone. The principal mines that have been operated in recent years are the Restauradora, Rosario and Carmelita. Another district of promise which has been fitfully worked for gold is the Cerro of Atajo, 6 miles northwest of the Capillitas. The mines are imbedded in decomposed trachytic rock in a network of mineral bodies with a surface composed of iron oxide mixed with auriferous quartz. The lodes of gold and copper are found in eruptive rocks.

Bolivia.—Rich alluvial and quartz deposits of gold are known to exist in a number of localities, some being above the line of perpetual snow. Up to the present time, however, the climate and lack of transportation have been drawbacks to any practical development. While no accurate information of the richness of the ores has been obtained, it is known that the Indians recovered considerable gold from the river beds. The quartz ledges have not been touched owing to the lack of proper machinery and competent miners to direct mining operations. Laborers for mining work can be obtained at wages ranging from 1·5 bolivianos to 4 bolivianos ($1·75) per day, according to the class of work to be performed. The report of the Huanchaca Mining Co. for 1899 gives a net profit of 680,207 bolivianos.† The product of Pulacayo mine was valued at 4,761,394 bolivianos. Cost of transporting it to the coast, 988,086 bolivianos. Net value of product 3,733,308 bolivianos, against 2,706,797 bolivianos for 1898. To the Bolivian Government 201,776 bolivianos were paid as export duties, and the cost of mining exploitation in 1899 was 3,121,316 bolivianos, against 2,795,-389 in 1898. This company will soon commence the tunnel to drain the water from the Pulacayo mines, the workings of which are now under water. Several years will be required to complete the undertaking. The agreement with the Guggenheims to operate the works at Playa Blanca has been renewed for seven years from October 1, 1900, which fact indicates that the smelting company derived profit from the treatment of the ore, a condition that the home company never attained. The Compañia Minera Mercedes de Oruro, with headquarters at Iquique, Chile, has been formed for the purpose of working the San José and Virgen silver mines near the well-known Oruro mines.

* Officiel Mémoire Général et Spécial les Mines dans la Republique Argentine, 1899, prepared for the Paris Exposition. † 1 boliviano = 43·8c. U. S. Currency.

Brazil.—During the past year operations in the productive mines have been on a somewhat increased scale, and there has been more activity in prospecting and development work than for several years past. The production of gold cannot be ascertained with exactness, as the Government does not compile any statistics, but on the basis of the reports of mining companies it is estimated at $2,642,060 in 1900, against $2,225,000 in 1899. No doubt the improved industrial conditions have been brought about to a large extent by the action of the Government in reducing the export tax on gold from 5 to 3·5%, and also in replacing the heavy import duties on imports of machinery, implements and other mining accessories, by a tax of 5% *ad valorem*. Auriferous deposits are found in various parts of the country, but nearly all the gold comes from a small district in the State of Minas Geraes. Here are located the Morro Velho, the Passagem, the Sâo Bento, the Vieira, the Santa Guiteria, the Cutao, and the Honorio Bicalho mines, the greater part being under English control. The report of the St. John del Rey Mining Co., which operated the Morro Velho mines for the six months ending August 31, 1900, shows that the sales of gold for that period realized £168,366. The working costs in Brazil amounted to £86,481, leaving a gross profit on the operations for the half year of £81,885. The company's plant includes a 200-stamp mill and 340 concentrators. The Ouro Preto Gold Mines of Brazil (Passagem mines) is next in importance to the St. John del Rey Mining Co. During the year ending June 30, 1900, the amount of gold taken out by this company was 22,425 standard oz. and the profit £13,167. The Sâo Bento Gold Estates, Ltd., in the same time crushed 15,851 tons of ore for a yield of 7,858 oz. bullion, and the Faria Gold Mining Co. of Brazil produced bullion to the value of £26,150. It is stated that the Tassara properties near Ouro Preto were sold to a syndicate for $700,000, and that the sale of other mines is being negotiated, which, if effected, will lead to their active development.

Colombia.—The continuation of hostilities has greatly hampered the mining industry of this country. The principal mining districts are Antioquia, Cauca, and Choco, where the precious metal is obtained by hydraulic mining, by dredging the beds of existing rivers and by working auriferous veins. The Anglo-American Exploration Co., capitalized at $5,000,000, has been organized in Delaware to operate mines and smelters mainly in Colombia. The Tolima Mining Co., operating the Frias and Plaza silver mines, gave the following data for 1899 in the director's report dated July 10, 1900; 13,704 tons of ore were dressed at a cost of $0·203 per ton, which yielded 577 tons of concentrates, valued at £20,334 3s. 5d. The cost, however, exceeded this amount, being £21,892 17s. 8·5d. Although the year's work was attended with the slight loss referred to, the developments made are regarded as very favorable for work in 1900.

Ecuador.—The mines in the Zaruma district, Province of Del Oro, are now being worked by the South American Co. of New York and, in a minor degree, by a native company called the National. The richness of ore varies from 1 to 4 oz. of gold per ton and the vein is from 1 to 1·5 m. in width, occasionally much wider. It is encased in porphyritic rock covering about 100 sq. km. The upper or surface veins carry free gold to a depth of 20 to 30 m. Below this the gold is found in combination with copper and iron pyrites.. In some

cases galena and zinc blende occur, with specks of pure copper. These ores yield from 0·75 to 1 oz. per ton, but in some instances pockets have yielded 30 oz. and in one case, a pocket yielded 300 oz. per ton. The bullion averages 73·04% gold and 26·06% silver. Motive power is afforded by the Amarillo and Calero rivers and timber is found in ample quantity. Transportation, however, is costly. Peons familiar with the business can be employed at from $0·60 to $0·80 per day United States gold, and native miners at from $1 to $1·20 per day; foreigners are engaged by contract. The climate is trying near the streams, even at an altitude of 2,000 ft., but the higher ranges are healthful. The temperature varies from 14 to 25°C. according to elevation. The district is 60 miles from the coast, but the transportation is slow and expensive, especially during the rainy season, as the roads are very bad. The mining is principally by drifts and the mines are self-draining. Placer mines exist in the district, but they have received as yet little attention. The placer mines near the rivers Santiago, Uimbi and Cachabi in the Province of Esmeraldas were early exploited but have been abandoned since the abolishment of slavery. These mines are at present in the hands of an American company and the most important details relating to them are as follows: At Santiago the deposit is of varying richness, from 2 to 20 m. in width. The rocks are porphyry, pyrite, syenite and granite easily decomposed. The Angostura mine, near the Playa de Oro, has extensive deposits of alluvial strata, but is not worked at present. The deposits at Uimbi and Cachabi rivers are worked in a very small way by the negroes. The following analyses of Esmeraldas gold have been given:

River.	Gold.	Silver.	River.	Gold.	Silver.
	%	%		%	%
Cayapas.....	87·39	12·61	Uumbi...	86·88	13·12
Sapayito.....	85·71	14·29	Cachabi	85·68	14·32
Santiago.....	86·98	13·02	Vagota.....	86·73	13·27

The liberal mining laws enacted in 1892 invite development. Properties can be acquired by natives or foreigners by simple denouncement (pre-emption) before the local authorities. Claims can cover 600 m. (1,968·5 ft.) by 200 m. (656 ft.); for placer mines and coal fields, 50,000 sq. m. (12,355 acres); 20 claims can be pre-empted by the same person. Possession is indefinite as to time, providing an annual tax of $25 is paid on claims worked and $8 on those not worked. Machinery and all mining supplies are exempt from custom duties and no fiscal duties are charged on concessions or sales.

Guiana.—British Guiana increased its production of gold slightly in 1900, the total being $2,286,918, against $2,238,040 in 1899. French Guiana produced $1,412,857, against $1,655,088, and Dutch Guiana $521,690, against $557,532. Nearly all the gold was obtained from alluvial deposits. According to J. H. Powell* the alluvial deposits of British Guiana are found in a stratum of gravel averaging 2 to 3 ft. thick of post-Tertiary age. Occasionally the gravel lies on the surface, but usually it is covered by from 4 to 7 ft. of soil and clay. The beds of creeks and creek flats and rarely the hillsides furnish the richer deposits.

* *Institution of Mining and Metallurgy*, Dec. 19, 1900.

Hydraulic mining cannot be carried out successfully owing to the lack of a sufficient head of water near the gold fields, and to the limited extent of the gravels. Washing in the "tom" or sluice are the methods by which practically all the gold is obtained. With the "tom" from 3 to 4 cu. yd. of gravel can be washed in 10 hours at a cost of about $1·80 per cu. yd., while the sluice is capable of treating 18 to 24 cu. yd. at a cost per cu. yd. of $1·20. The average yield of gold throughout the colony ranges from 1·5 to 2 dwts. per cu. yd. Several attempts have been made at quartz mining, but largely through mismanagement they have proved unsuccessful. The gold output of French Guiana for the past few years has come largely from placer working on the southern border, an area that according to a recent boundary decision belongs to Brazil. This country is very rough and it presents great difficulties in access and transportation which will retard its future development. The most valuable gold deposits of Dutch Guiana are located on the Surinam River, about 65 miles from Paramaribo. Placer workings in a few instances have yielded good returns, but conditions generally are unfavorable for successful mining owing to the lack of water, intense heat, and difficulties of securing labor and cheap transportation.

Peru.—Gold mining in Peru has been gaining in importance in the last few years. The construction of railways, the founding of the School of Mines and Engineering at Lima and the erection of new metallurgical works with improved methods of treatment have been important factors in the improvement. One-half of the total output comes from the Department of Puno, which includes within its boundaries the Santo Domingo vein and numerous placer workings, while the remainder is produced by the Andaray, the Gigante and the Chuquitambo mines and various exploitations of small importance in Piura, La Libertad, Huánuco, Ayacucho, Apurimac and Cuzco. The Santa Domingo vein, which is worked by the Inca Mining Co., lies 212 km. from Tirapata, on the railway from Juliaca to Sicuaní. The mines and works are supplied with modern machinery, including an electric light plant, two 10-stamp batteries capable of crushing 30 tons of quartz per day, and a chlorination plant. The present output is $75,000 per month. The ore varies from 2·8 to 53 oz. of gold per ton. The Andaray company treats 12 to 14 tons of ore per day, extracting therefrom 10 to 12 oz. of gold. The Gigante mines are located in Pataz, east of Huallaga. They are equipped with the only cyanide plant in Peru. The ore is rich, assaying as high as 8 oz. per ton with a mean tenor of 1·5 to 2 oz.

The reduction works for silver ores of Ticapampa are located on the left bank of the Santa River, near Recuay, at an elevation of 3,400 m. above the sea. The ore is transported on the backs of horses or mules in sacks holding 70 kg. At the works the ore is first ground in a No. 4 Krupp ball-mill to 70-mesh and is then subjected to a chloridizing roast in a reverberatory furnace of the Mansfeld type, after which it is amalgamated. This process is carried out in copper pans of 1·1 m. diameter, and 0·5 m. depth, provided with steam feed pipes and mechanical stirrers. About 350 liters of a solution of cuprous and calcium chlorides (recovered from previous operations) are run into the pan and brought to the boiling point by steam. Three or four kg. of lime are then added and 460 kg. of ore. The whole is constantly agitated for 45 minutes when the silver

chloride, now completely reduced to a metallic state, is amalgamated with mercury that has been spread over the sides of the pan. By this method the loss of quicksilver by chemical reaction is reduced to a minimum amounting to about 15% by weight of the silver recovered. The loss in weight of the copper pan averages about 1 kg. for every 400 g. of silver. About 61,000 kg. of silver bars have been turned out during the last ten years.

According to the *Boletin de Mines,* October, 1900, of Lima, a concession has been granted to Emile Delallee and Fernando Fuchs for the exclusive privilege of dredging the Inambari River and its tributaries. The gold-bearing sands of this district have been famous, and through the construction of canals, water works and other installations necessary for the treatment, the region promises to develop into considerable importance.

Uruguay.—The only gold mines in operation are in the Department of Rivera, where l'Etablissements Français de l'Uruguay has acquired several of the more important mines of the auriferous region of Corrales and Cuñapirú. This company contemplates the construction of a railway connecting with the Usina Central to connect all mines and to utilize for traction and working the 360 H.P. generated by turbines on the Cuñapirú. With this in view the company has petitioned the Government for exemption of custom duties on certain materials to be imported. The production of gold in 1898 from 5,235·5 tons of ore was 74·7 kg., which gives a value of $6·35 per ton and a total value of $33,246, Uruguayan currency. The richness of the ores treated has increased from the average per ton in 1895 of $3·45 to $6·35 in 1898.

Venezuela.—Although 24 mining companies have erected a total of 583 stamps, there are according to G. Percy Ashmore* only two—the Caratal (new) Mines, Ltd., and the Goldfields of Venezuela—now in operation. This inactivity is due to the disturbed political condition of the country, there having existed a continuous revolution since 1893. The entire Caratal district is alluvial ground and is worked in a most primitive manner. To secure the gold round pits or *barrancos* 4 ft. in diameter are dug until the pay dirt is reached and removed. The dirt in sacks is carried to the river and washed in wooden bateas, and mercury usually is added. The Yuruary River is rich in alluvial gold. It is now being dredged by an American company. The reef gold is both coarse and fine, and is free milling in most cases.

EUROPE.—*Russia.*—The gold production in Russia during 1900 was reported at 1,117,054 oz., against 1,159,214 oz. in 1899. About 90% of the total yield is derived from alluvial workings. Favorable changes in the mining laws will hasten the development of the gold mining industry, and small producers are now permitted to sell their dust to other producers instead of taking it personally to the government assay office. The government tax on gold, hitherto varying from 3 to 10% on the gross output in different parts of the country, is being reduced to a uniform rate of 3%. The recently constructed Trans-Siberian Railway will be of marked aid in the development of gold mining, and machinery for gold working in Siberia and the Urals is now duty free under certain conditions, which exemption will continue until January, 1909. The clandestine sale

* A paper read before the Institution of Mining and Metallurgy, March, 1900.

of gold dust to mine owners by peasants has always been prevalent and has made the government statistics of the production of individual mines unsafe for prospective purchasers to base estimates upon. During the summer an expedition of the East Siberian Syndicate, Ltd., of London, prospected the shore of the Chukhotsk Peninsula of eastern Siberia on its Arctic and Bering Sea coasts, this being an imperial concession to Colonel Vonlarlarsky. The moving spirit of the enterprise was George D. Roberts and the nominal head of the exploring party was a Russian geologist, Carl Bogdanovich. Geological conditions and formations similar to those of the Nome region and Seward Peninsula were encountered at several points, but no encouraging mineral prospects are reported. Up to the present time there has been but a comparatively small amount of quartz-mining in Siberia. The bulk of the output has been from alluvial deposits and these placers have been worked either by primitive rockers or by sluicing. The largest of the crude washing machines in use, operated by steam power, has a capacity of 750 cu. yd. per 24 hours, involving the labor of 100 men and from 40 to 60 horses, and it saves but 80% of the gold at a cost of from 16 to 23c. per cu. yd. There is an immense amount of material in the older regions not quite rich enough for hand working which could be treated probably by modern methods. The new regulation of last year, admitting gold mining machinery free of duty, has resulted in a number of dredging schemes. Mr. Daniel F. Keating has recently taken a large plant into central Siberia and his success or failure is awaited with great interest by Russians. During the season of 1900 the Astaskef Co., a Russian concern, operated a dredge on the Kiya River of the Marinsk district, West Siberia; a steady product of $100 a day of 16 hours' work was made, and it was found that gravels carrying 7c. per cu. yd. could be worked at a profit. In the Achinsk district, Messrs. Brown, McCormick and Egbert have leased a large placer from Mr. C. C. Ivanitsky for a period of five years and will put in a hydraulic plant. Mr. C. W. Purington has recently completed an examination of a newly found quartz mining district in the mountains at the head waters of the Sarela, a tributary of the Yenisei, about 100 miles south of the Trans-Siberian Railroad. Little development work has been done, but many quartz veins, apparently regular leads, showed on the surface and displayed free gold. One vein, opened up by 200 ft. of open cut and 100 ft. of tunneling, was 20 ft. wide from wall to wall. A primitive mill treated 500 tons and the gold extracted averaged in value $18 per ton. There is unlimited water power and cheap fuel in this district. In addition to the quartz leads found recently in the Sarela country, remarkable veins bearing free gold are now being uncovered in the Marinsk district of West Siberia. Small and inefficient quartz mills have been operating for several years on the Onon River to the southeast of Irkutsk, and have been operated profitably despite bad management. Mr. O. A. Nestergard, a missionary from Mongolia, reports very rich quartz finds on the Siberian-Mongolian frontier, to the north of Urga. In general it may be said that prospecting for quartz-leads in the American sense is almost unknown in Siberia, and that such finds as have been made are nearly all the result of accident. M. de Batz, in his recent work, *Les Gisments Auriferes de Siberie,* is of the opinion that the auriferous pyrites in the Silurian or Devonian mud is the source of gold

in Siberia. Dr. F. R. Carpenter, in his paper on "Pyritic Smelting in the Black Hills," read before the American Institute of Mining Engineers, August, 1900, states his belief that the process proposed some time ago for smelting the Siberian black sands, so that the gold might be recovered in metallic iron, is perfectly feasible. His results from pyritic smelting in the Black Hills, S. Dak., gave evidence that the reduced iron carried the gold.

Servia.—Ten gold mining concessions in the northeastern districts have been granted to different parties, the most important being in the valley of Timok, Department of Kraïna, held by Mr. George Weifert. Analysis of picked ore sent to Schemnitz for smelting showed it to contain 40% pyrite that yielded 103 g. gold per ton. Local amalgamation gave 6 g. gold and from 40 to 70 g. concentrates per ton.

Spain.—Janssen & Co. of Louvain, Belgium, have purchased three auriferous arsenopyrite mines and have erected a wire tramway to the sea for the shipment of the ore. Many concessions of iron and arsenical pyrites have been taken up between Retanzos and Ferrol by Mr. Barcon. Baylis & Co. are operating their auriferous arsenopyrite mines at Monfero. The Sagasta Mining Co. has increased its water power from the river Ayones in order to mill large quantities of gold ores from the Sagasta and Alfonso XII. gold mine.

United Kingdom.—The St. David's Gold & Copper Mines produced gold bullion and concentrates in 1900 to the value of £51,344, earning a net profit of £39,729. A new company called the Voel Mines, Ltd., has been organized with £160,000 capital stock to operate properties in Merionethshire, adjoining those of the St. David's mine. The Welsh deposits have attracted considerable attention lately, although previous attempts to work them have not met with financial success.

AFRICA.—*Abyssinia.*—Gold in the form of rings and nuggets is brought into Harrar from the Wallega, the Bemschongul and the Shinkalla countries. The annual export from Abyssinia amounts to about 15,000 oz., valued at $17 to $18 per oz. A company has been formed to work gold deposits in the Italian colony of Erythrea.

German East Africa.—It is reported that gold veins have been discovered in German East Africa on the shores of Lake Nyanza.

German West Africa.—The discovery of a mineralized zone containing gold, silver, copper and lead is reported in a district about 400 miles inland from Walfisch Bay. The Anglo-German West Africa Co. has taken measures to explore the territory and if favorable results are obtained it will push its development.

Gold Coast.—The Gold Coast Colony and protectorate covers an area of 40,000 sq. miles, which fronts on the coast for 350 miles and has an average breadth of 100 miles. The Gold Coast proper is situated between lagoons, with shores of harder formation, containing occasional sand pits and peninsulas. The coast is difficult of access, as harbors are lacking and sand bars block the mouths of the rivers. A landing stage is now being constructed at Sekondi, and a Government appropriation has recently been made for the construction of a railway to Tarkwa and Kumasi, which will pass along the gold belt from the noted Banket Reef at Tarkwa. It is expected that the line from Sekondi to Tarkwa, which now extends

as far as Bansu, will be in operation by May, 1901. The annual export of gold from the Gold Coast from 1886 to 1891 averaged in value £87,500. It was £88,000 in 1891, and in 1892 it reached the total of £99,000. The product represents gold dust, mainly from alluvial deposits that are found in the hills, along the rivers and on the seashore. Nearly 125 companies have been formed in the United Kingdom to mine gold on the Gold Coast. Among the more recently organized are the following: Ashanti Gold Fields Corporation, West African Mining Co., Ashanti Mines, Ltd., the Ashanti Sansu Mine, Ltd., Atassi Mines, Ltd., Bibiani Gold Fields, Ltd., Claude's Ashanti Gold Fields, Ltd., Gold Coast Investment Co., Wassau Mining Co., Ltd. The total capitalization of the companies enumerated is over £2,500,000. Of the older companies now producing, may be noted the Tarkwa and Abosso Co., Ltd., with 30 stamps, and the Wassau Mining Co., Ltd., which is operating the Cinnamon Bippo and Adjak Bippo mines. A formation similar to the banket deposits of the Witwatersrand is said to have been proved over an area of 25 sq. miles. The Gold Coast Agency, Ltd., backed by the Consolidated Gold Fields of South Africa, Ltd., is boring with a diamond drill at Cinnamon Bippo for the deep level of the Wassau Reef. A depth of 850 ft. has already been reached and it is proposed to continue to a depth of 3,000 ft. The reef where operated by the Wassau company is reported to yield an average value of $30 per ton. The Ashanti Gold Fields Corporation, Ltd., has a concession of 100 sq. miles of auriferous territory, and has been at work for the last three years. It employs a staff of 80 Europeans at the mine at Obuassi. There are 25 stamps erected and 60 more in course of erection, which will be operated by water power. At the close of last year the company had crushed 5,000 tons of ore for a yield of 12,000 oz. of gold.

Madagascar.—The discovery of rich gold deposits in the valley of the Ampasary River is reported. It is stated that the output from this field alone amounts to about 200 kg. per month.

Portuguese East Africa.—A. R. Sawyer states that the Manica Gold Field, comprising an area of about 180 sq. miles, is formed by an eastern extension of the Umtali field of Rhodesia. Alluvial workings have been found, showing that gold was obtained here in ancient times. At present the quartz reefs are being prospected with encouraging results.

Rhodesia.—The production for 1900, according to the Rhodesia Chamber of Mines, was 79,354 fine oz., being an increase of 25,113 oz. over the output for the preceding year. The monthly returns averaged about 6,000 oz. up to August, when over 10,000 oz. were reported and the production remained at about that figure for the remainder of the year. The most important producers were the Globe & Phœnix, Dunraven, Alice Proprietary and Rezende mines. Much difficulty was encountered throughout the year in securing satisfactory labor. The natives of Mashonaland are both unskilled and unreliable, which necessitates the importation of workmen from other parts of Africa.

The Alice mine resumed crushing operations in September, 1900, and up to January 1, 1901, treated 3,507 tons of ore, which yielded 2,635 oz. gold.

During the year* there were 18 mills, with 279 stamps operating in this terri-

* *Statist*, Oct. 6, 1900.

tory, and 393 additional stamps are being erected, which will bring the total to 672 stamps. More than half of those now operated weigh above 1,000 lb. each. The cyanide process is being introduced at a number of the works, notably the Bonsor Gold Mining Co. and the Geelong Mining Co.

The geology of Rhodesia, according to R. R. Matson,* shows great irregularity in the distribution of the different formations. Stretches of granite country alternate with loose disintegrated granite, which is followed by a schistose red-earth region, in which the gold ores are almost always included. The mining laws allow the mining companies to follow the reefs indefinitely and are not limited to the extent of the surface ground. It is said that the mines show indubitable evidence of having been worked by the ancients, whose operations, however, were limited to depths less than 250 ft.

Transvaal.—Martial law was declared by the South African Republic on October 15, 1899, and the mines were under its administration from that time until the evacuation of Johannesburg before the British troops, which occurred in May, 1900. Early in October preparations were made by the Government to work the richer mines, and it is reported that in the latter part of the month eight were in operation. This number was afterward increased to 12, of which five were operated under direct Government control with new managers and staff, and seven under Government supervision, but with the companies' officers. A sufficient number of native laborers were held in Johannesburg to carry on the operations. The output of the mines for the first three months of 1900, as reported by the State Engineer in charge, was: January, 90,795 oz.; February, 75,136 oz.; March, 85,834 oz.; total, 251,765 crude oz. No official figures for the remaining time have been given out. A full statement of the production was prepared by Mr. E. Boucher, from which the following statistics were compiled and communicated by Mr. Francis Drake of Johannesburg, the returns being in fine ounces: October, 1899, 26,904; November, 55,941; December, 68,525; January, 1900, 80,785; February, 64,408; March, 84,546; April, 54,772; May, 64,249; total, 500,130. According to this statement the output for 1900 was 348,760 fine ounces, or $7,208,869. The yield of the different mines for the full time of their operation under the Boer Government was: Robinson, 119,326 oz.; Ferreira Deep, 58,168 oz.; Rose Deep, 44,927; Bonanza, 59,445; Crown Reef, 13,873; Village Main Reef, 53,209; Ferreira, 61,921; Wemmer, 52,610; Geldenhuis Estate, 12,077; Langlaagte Deep, 10,720; Worcester, 9,885; Pioneer, 3,969; of the total output, 339,346 oz. were recovered by amalgamation, 35,553 oz. by chlorination and cyanidation of the concentrates, 124,053 oz. from the tailings and 1,178 oz. from by-products. The quantity of ore milled was 684,051 tons, yielding on an average 14·6 dwt. per ton. A Government refinery was established where the bullion was treated and sent to the mint for coinage.

For a full description of the mining industry during the war reference should be made to the series of articles that appeared in *The Engineering and Mining Journal,* beginning with the issue of March 10, 1900.

At the opening of hostilities the mines under English management, the

* *Engineering Magazine*, March, 1900.

stock of which was owned mostly in England, began to curtail production, but did not close down entirely, as the Transvaal law declared that mines ceasing operations without tangible reasons were subject to confiscation. It became apparent early in December, however, that the war would be stubbornly contested by the Boers, and most of the English in Johannesburg preferred or were invited to leave. From that time until late in the spring of 1900, the English mines were shut down completely, even pumping being stopped. In 30 of the mines under German or French management, besides those enumerated as active producers, pumping was continued by the Government and they were kept in fairly good condition. A committee was also appointed early in 1900 to represent the German and French stockholders in the mines that had been commandeered. According to the report of the Government Surveyor the conditions at these mines were unfavorable for working. In some cases the plans were incomplete or had been secreted, necessitating detailed measurements and surveys before production could be resumed.

The seizure of Johannesburg by the British in May, 1900, was followed by the re-establishment of martial law with strict enforcement, and little could be done at that time toward investigating the conditions of the mines. The reports of the companies, so far as made, showed that little wilful damage had been done during the Boer occupation. In a few cases tools and machinery had been removed or disarranged by unskillful handling. A number of the mines were full of water, while the mills had suffered somewhat from disuse. In nearly all of the mines, production could have been resumed after a month's preparatory work. The necessities of the military occupation, however, prevented any extensive resumption of operations during the year.

One of the chief difficulties which the mining companies have to meet is the collection and reorganization of the native working force. A few of the laborers were retained by the Boer Government for its own use, but the majority have been widely scattered and the collection and new training of an efficient force will be a work of time and difficulty. The war has had a demoralizing effect on many of them and it will take some time before they realize the new order of things. It is indeed one of the few fortunate incidents of the war that the natives took no advantage of the conflict to assert themselves in any forcible way.

Considerable agitation among the South African shareholders was aroused by the plan of the British Government to charge as large a part as possible of the cost of the war upon the future revenues of the Transvaal. As there will be for some time to come very little property outside of the Rand district able to pay taxes, this burden will fall almost entirely upon the mines. It is not improbable that the savings made by the abolition of monopolies will be counterbalanced by increased taxation.

ASIA.—*Borneo.*—The Borneo Co., Ltd., an English concern, is operating mills at Bau and Bidi which, in 1900, crushed about 10,000 tons of ore per month. The output of the company in 1899 was 12,150 oz. The Kehajan Co. is constructing a railroad from the 20-stamp mill on the river to its mines 8 miles distant. It is reported that the Sourabaya Syndicate, which holds concessions

on the Melawi River, will commence dredging operations on a large scale during 1901.

Dutch East Indies.—It is now apparent that some well directed and promising enterprises are coming out of the flurry of mining speculation which arose in the Dutch East Indian fields two years ago. The existence of excellent ores of gold, silver, copper and lead is credibly reported and actual developments have now gone beyond the prospecting stage. In the fall of 1900 two companies in Celebes were producing gold and beginning to operate their own stamps—both having 10-head batteries. One, the Palelah Co., had previously shipped to Europe 1,000 tons of ore, averaging over 5 oz. per ton. This was the more encouraging as the deepest shaft on the island had not been sunk below the 200-ft. level. During the past year the Palelah completed a wire rope tramway and erected 20 additional stamps, which gives a capacity of producing $40,000 gold per month. In Sumatra the Redjang-Lebong Co. was even more successful. It began crushing with five stamps in December, 1899, and in September, 1900, it had 20 stamps at work and was busily erecting 20 additional stamps as well as a filter-press slime plant. The ore is comparatively high grade, assaying about 1 oz. gold and 8 oz. silver per ton, and the bulk of its product is extracted by the cyanide plant. During August its gold output was 1,350 oz. from milling, and 8,500 oz. silver from the cyanide plant. A great increase in its production was anticipated upon the completion of an adit, draining the reef at the 150-ft. level. In advance of this drainage, it has only been able to mill ore from the old workings, which the original miners rejected. It is reported that the lode or reef has a developed length of 1,000 ft. and an average width of 18 ft. The Soemalata Co., at the end of 1900, was producing at the rate of $16,000 per month (40,000 guilders). The capacity of the plant is 100 tons of ore per day, averaging about 1 oz. gold and 1·5 to 2% Cu. The ore is matted by the pyritic process, a concentration of 8 into 1 being made, and the product shipped to Germany for treatment. The cost of smelting is extremely low. Cooly labor is obtained at 15c. per day and the cost of fuel is very slight. The Totok Co. produces about $3,000 gold per month at a cost which leaves little if any profit. Although the gold mines are chiefly in Sumatra and Celebes, the headquarters of most of the companies are in Batavia, on the island of Java, the commercial center of the Dutch colonies.

China.—The outbreak of the war blocked all mining undertakings by foreign enterprise in China during the past year. Whatever may be the outcome of existing uncertainties, a remarkable advance in the development of mineral lands is assured as soon as there shall be a reasonable prospect of stable conditions either under a reform government or a division of the Empire. Even during the war there has been a marked advance in the general knowledge and appreciation of the mineral resources of China. Syndicates have been competing for a hold on the rich metalliferous and coal fields of northern China, and in the event of a partition of the Empire, few provinces would be more coveted than Chi-li, Shan-tung and Manchuria. Chi-li lies in the northernmost part of China and its mountainous portion has been prolific in gold, silver, lead and copper from remote antiquity. Shan-tung covers the Liao-tung Peninsula,

and examining engineers have noted the extraordinary field for development in both these provinces. Mining in China, although very ancient, has been exceedingly crude and limited. When the mines reached the water level, further progress was rarely attempted, and the principal mines were long ago carried to this level and abandoned. Within the past 20 years there has been an attempt to introduce modern methods in a tentative way with the permission of Prince Li Hung Chang. Copper mines were opened under European engineers in 1883, near Pa-kou in Chi-li; gold mines at Ping-tu in Shan-tung in 1884, the silver-lead mines at Ku-shan-tzu in Chi-li in 1888. Unfortunately these ventures were not largely rewarded, though most of these mines have since been worked by the natives without much profit to the owners. New mines were also opened with no more success at other localities. The product of gold from Chi-li mines, operated under official cognizance, was nearly 50,000 oz. in 1898. Gold occurs in many places in this province, but in Shan-tung it has only been found in a few isolated districts, which yielded in the same year (1898) 6,000 oz. The product of silver from legalized mines in Chi-li in 1898 was approximately 140,000 oz. H. C. Hoover, in a paper read before the Institution of Mining and Metallurgy, March 28, 1900, states that he found gold in three forms of deposits in northern China: (1) Quartz, (2) possible impregnations of limestone, (3) alluvial. The gold veins occurring in the older rocks are of two classes—normal fissure quartz veins and gash veins. Superficial decomposition is generally shallow. (1) The fissure veins contract in depth into veins carrying a large percentage of sulphides, or appear as wide veins of low-grade, milky-white quartz, showing almost exclusively iron sulphides in large masses. The gash veins common in Chi-li average 3 to 6 in. in width and are exceedingly erratic. (2) The impregnated limestones have been so imperfectly developed that little is definitely known about them. (3) The alluvial deposits throughout the mountains have been thus far the main source of the gold output. The filled valleys are always the course of a considerable stream, and the attempts of the Chinese to reach the real bed rock have been unsuccessful, owing to lack of means for overcoming the water. What might be effected with adequate engineering is indicated by the enormous returns from the buried basin at Ching-ch'ang-kou-laing, drained by a tunnel.

Silver lead mines have been worked at Je-Holm in Chi-li. The mines carry well-distributed argentiferous galena in small quantities and often masses in seams 1 ft. wide and ranging up to 200 ft. in length of solid galena yield 500 oz. silver per ton. The metal occurs as sulphide, chloride and ruby silver, and is associated with lead, zinc, arsenic and antimony sulphides with no traceable gold. The rich ore bodies are very erratic and foreign methods of working have thus far failed. No silver deposits of any consequence have been found in Shan-tung.

The Russian developments in the Sungari region of eastern Manchuria are already of great promise. In 1899 M. Mosskvin, a gold miner of Semipalatinsk, obtained a concession from the local Chinese authorities for the working of mines in this region. Under this agreement expert Russian miners were brought into the province and mining plants erected. In the Sungari Mountains, two Russian establishments were in full operation in the summer of 1900 and extraordinary

returns were reported. In the valley of the river Shagun there are vast amounts of auriferous earth on the surface, which has been only partially worked in the most primitive fashion. The average wages of the native laborer in the Chinese mines is 6d. a day, but his efficiency is only one-fifth that of the European laborer. Coal could be obtained at 8s. per ton if proper transportation were provided. Water is everywhere abundant and in many places water power could be developed. Tools, dynamite and mining supplies generally must be imported. Working costs of gold mining under foreign administration should not exceed 20s. per ton in narrow veins, and large deposits could be developed in competition with any other mining territory in the world.

India.—There has been a steady increase in the gold output of this country since the opening of the Colar district some 30 years ago. The total production in 1900 amounted to 505,580 crude oz., against 457,020 crude oz. in 1899, of which about 10,000 oz. each year came from Burma, Madras and Nizam's Territory, while the remainder was mined in the Colar field of Mysore. At present there are nine productive mines in this field, the most important being the Mysore, Champion Reef, Ooregum and Nundydroog. The Mysore Gold Mining Co., for the year 1900, reports the treatment of 116,576 tons of ore, yielding 142,868 oz. gold, 153,423 tons of tailings and slimes, yielding 19,024 oz. gold, while 1,241 oz. gold were saved from the scaling of the plates in the No. 1 mill, bringing the total to 163,133 oz. gold. The net profit for the year was £401,747, which, with the balance at the beginning of the year, gave £403,775 to be distributed. Dividends of 13s. 6d. per share were declared, which amounted to 135% on the former holdings of £250,000. The company secured authority to issue 30,000 additional 10s. shares at the price of £5 per share, which added £150,000 to the capital resources, while increasing the nominal capital by only £15,000. The Champion Reef Gold Mining Co. of India, Ltd., according to the report for the fiscal year ending September 30, 1900, produced 163,947 oz. gold, valued at £618,743, against 154,802 oz., valued at £584,048 in 1899. The profit for the year amounted to £351,736, out of which two interim dividends of 4s. per share, amounting to £176,000 have been paid. Other specified payments left a disposable balance of £111,939. An additional 5s. dividend was proposed for January, 1901, which would bring the total dividend distribution for the year to 13s. per share, equaling 130% upon the nominal capital. A new 20-stamp mill has been constructed and the old pan tailings plant converted into a 400-ton cyanide works. The average yield in gold per ton was 1 oz. 10 dwt. 14 grains, against 1 oz. 7 dwt. 13 grains for the previous year.

The Nundydroog Co., Ltd., milled 37,460 tons of ore, yielding 41,734 oz. gold and cyanided 60,409 tons tailings for 7,031 oz., the total output during the year being 44,491 oz. The profits of the year's operations were £91,019.

An arrangement has been entered into between the Mysore Government and the Colar mines, whereby the latter are to be supplied with power electricity transmitted from the Cauverny falls, 90 miles distant. The power will be used to operate mills, air compressors and other machinery, and will undoubtedly effect a reduction in working costs.

Burma.—In Burma, during 1900, there has been a concentration of effort

in the examination and development of the Wuntho district, the most promising known field for mining exploration. A number of narrow, gold-bearing quartz veins have been located here, according to the report of the Geological Survey of India, but their profitable working seems to depend on the feasibility of combination if the continuance of ore with depth is demonstrated. The only important operations thus far are on the line of the Choukpazat vein, or reef, as it is called, and neighboring parallel reefs. The croppings of this reef were first discovered by Burmese and rudely worked for gold until 1894, when a white prospector undertook to develop its extent systematically. It is 240 ft. in length and varies in width from 2 in. to 10 ft., with an average thickness, so far as traced, of 2·5 ft. Inclines have been sunk on its slope to the 310-ft. level, and the continuance of the vein proved by boring to a depth of 110 ft. farther. The gangue is quartz, generally white, but occasionally banded with black streaks. It is reported to carry 14 dwt. gold to the ton. The croppings of three parallel veins of like character have been worked within a distance ranging from 900 yd. to half a mile, and some ore has been taken out, but its average yield has not yet been determined. For the development of the main vein and prospective additions, a 10-head stamp battery and a small cyanide plant have been erected at Choukpazat.

Japan.—From very early times placer gold has been found along the river courses of Jesso Island, but the yield was so trifling that this field attracted little attention until 1898, when gold placers of considerable extent were discovered in the Province of Kitami, in northern Jesso, and, in the following year, it is estimated that 7,000 persons were at work in the gold field, which was most prolific along the branches of the Tambetsu and Horobetsu rivers. Nuggets were of rare occurrence and none weighing more than half an ounce is reported. The extreme fineness of the dust, the inexperience of the workers and the crudity of their appliances made the percentage of loss heavy. The total output for the year was reported to be only 990 lb., valued at $246,016. During the past year the workings have been extended, but still in a very crude and wasteful manner.

A company has lately been formed by foreign promoters in Yokohama, which has acquired a reported concession of 37 acres of placer ground that will be worked by modern methods. Its operations may give some accurate measure of the possible yield of the placers, whose area is computed by one of the native papers to be 1,500,000 acres. Under the mining laws prior to 1900, no foreigner has been allowed to engage in the mining industry, or even to be the holder of shares in mining undertakings, but a modification of this disability has since been effected, which may admit of the development of Japan fields by foreign initiative.

Korea.—The advance of gold mining in Korea during 1899 and 1900 has been noteworthy. The gold export of the country increased £55,765 in 1899. The gold mines under American control at Woonsan were reported to be in full working order in the fall of 1900, and the mines operated by German investors were in process of development. A British syndicate, headed by Mr. Pritchard-Morgan, secured in March, 1900, undisputed possession of the Unsan

gold mine, reputed to be the richest in the country and popularly known as the "Pearl of Korea." This mine is now in active operation, with a force of 500 men, mostly Koreans, and mining and milling machinery for its development is under construction in England. The Unsan district has been re-named Gwendolin, to prevent confusion with the Woonsan mines. A recent British consular report asserts that the gold-bearing stratum is a sedimentary deposit of great extent and similar in respects to the Witwatersrand.

Malay Peninsula.—Mr. Machado, the manager of the Jelai Tin Syndicate, reports that old and extensive alluvial workings were found at the Sungei Nhintoo River. At one place, between walls of sandstone, was found a 6-in. string of quartz that yielded to the pick in brick-like cakes. The material assayed 6 oz. gold per ton. Every dish of alluvial dirt yields from 5 to 20 colors of gold. Whether this gold was derived from the disintegrated quartz strings, similar to the one discovered, or whether it was due to some source further up the stream, was not determined.

AUSTRALASIA.—(Through the courtesy of T. A. Coghlan, Government Statistician of New South Wales, special notes on the mining industries of the colonies have been incorporated in the following review.) The union of the individual colonies into the commonwealth of Australia will benefit the gold mining industry, and the adoption of a uniform tariff will favor the importation of mining machinery. Many smelting works have been established in recent years, with the result of greatly lessening the quantity of ore exported. The dredging of river beds and alluvial flats for gold is an important feature in mining industries planned for New Zealand, New South Wales, Victoria and Queensland. Although gold dredging has been carried out successfully for some time in New Zealand, it was only during the last two years that this class of mining was introduced into New South Wales and the other colonies. Considerable improvement has been effected in construction, particularly that of the gold saving appliances. Many of the auriferous flats have been worked already by fossickers, but in a crude way only, so that a large percentage of gold still remains to be recovered, particularly the fine gold. The production of gold in Australasia for 1899 and 1900 is detailed in the subjoined table, from which it will be seen that during 1900 there was a decrease in the yield from each individual State.

PRODUCTION OF GOLD IN AUSTRALASIA.

Colonies.	1899.			1900.		
	Crude Oz.	Fine Oz.	Value.	Crude Oz.	Fine Oz.	Value.
New South Wales	496,196	412,401	$8,524,332	345,650	281,207	$5,812,539
New Zealand	389,558	356,222	7,363,100	371,993	337,337	6,972,749
Queensland	946,894	668,164	13,810,947	951,065	662,036	13,684,284
South Australia	32,857	28,750	594,263	29,397	25,713	531,498
Tasmania	83,992	77,109	1,593,835	80,130	73,578	1,520,867
Victoria	854,500	804,644	16,631,988	807,407	760,142	15,712,140
Western Australia	1,643,876	1,462,840	30,236,907	1,580,950	1,414,273	29,233,033
Totals	4,447,873	3,810,130	$78,755,372	4,166,592	3,554,286	$73,467,110

New South Wales.—There was a remarkable decrease in the gold production in this State during 1900 as compared with 1899, the statistics for the two years being respectively 345,650 crude oz. ($5,812,539) and 496,196 crude oz.

($8,524,332). As stated in THE MINERAL INDUSTRY, Vol. VIII., it was difficult to determine the cause of the greatly increased yield for 1899. The approximation of the production of 1900 to that of 1898, when it was 341,722 crude oz. ($6,055,070), suggests the possibility that some West Australian gold was inadvertently included in the returns from New South Wales for 1899.

The principal alluvial districts are at Bathurst and Mudgee, the country watered by the feeders of the Upper Lachan as well as the Tumut, Adelong and Braidwood districts being of minor importance. The principal quartz veins are situated near Adelong, Armidale, Bathurst, Hill End, Orange, Parkes and Wyalong. The dredging fields of New South Wales compare well with those of New Zealand, and they give promise of returns as satisfactory when the industry shall have been fairly started. To encourage mine owners to reach the reefs and alluvial deposits at greater depths than are now being worked, the Government has offered a reward of £2,000 for the discovery of payable quartz or alluvial at a depth of 1,500 ft., the amount to be increased to £3,000 when a depth of 2,000 ft. has been attained. At present the deepest mine in the colony is but little over 1,000 ft. in depth, while in Victoria payable ore is being raised in 12 mines from depths approximating 3,000 ft. Extensive additions of machinery have been made at several of the principal mines at Cobar, particularly at the plant of the Cobar Gold Mines, Ltd., a company that deserves great credit for its efforts in solving the problem whether the very low grade ores which occur in large quantities at Fort Bourke could be treated with profit. At first the ores were amalgamated directly, a treatment that resulted in failure. Later, with improved machinery and its new $50,000 cyanide plant, the company's net profits were £20,972 for the fiscal year ending September 30, 1900. The cost of working per ton of ore in the Cobar district is reported to be: Mining, 3s. 6d.; milling, 2s. 6d.; cyaniding, 3s. 1d.; a total of 9s. 1d.

New Zealand.—There was a slight decrease in the gold production during 1900 as compared to 1899, although the yield of the first named year greatly exceeded that of 1898 (254,416 fine oz.). The improved appliances introduced in dredging and hydraulic elevating and sluicing machinery have made it possible to treat material at a cost of from 1d. to 3d. per cu. yd., so that alluvial drifts containing only a few grains of gold to the ton can be profitably worked. The greater part of the gold yield of the colony is contributed by the Otago and Southland districts. Hydraulic mining has not been very active during 1899-1900, owing to the greater interest attracted to the development of dredging. The number of dredges in Otago and Southland on March 31, 1900, was 97, of which 81 were in operation. In addition, 101 new plants were under construction. While good returns have been made in many instances, the large number of flotations will cause some suffering to investors. The Mines Department now has in view the development of a method whereby the surface soil and clay can be first stripped and subsequently deposited on the tailings, well behind the dredge. In this manner the land is fairly well restored and the auriferous gravel can be treated without admixture of clay. A dredge recently designed to work on Frazer Flat, near Alexandria, has a hull length of 116 ft. and is operated by a 25 H.P. engine. The ladder extends 40 ft. below the surface and the

buckets are of 7 cu. ft. capacity. The elevator for the tailings is 145 ft. in length and is capable of stacking them 80 ft. above the water line. The value of dredging interests in the district is estimated at $12,500,000. The Waihi Mining Co., in 1899, treated 102,381 tons of ore, yielding 66,053 oz. gold and 189,149 oz. silver, valued at £302,525, giving an average of £2 19s. per ton; £128,000 were paid as dividends and a balance of £40,564 carried forward to 1900; 190 stamps were operated in 1899. The actual saving was 88·4% of the gold content and 57·6% of the silver content. The cost of cyaniding is slightly under 51·5c. per ton of ore; 100 new stamps were added in 1900 and were worked by the wet process; should results warrant, the entire mill will be changed to this method. It is worthy of note that the change from dry to wet crushing has already been made in other batteries in the northern gold fields. The Waihi Mining Co. has absorbed the old Martha company, which tried to operate the mine in a small way without success. Under the new control, however, the equipment of 200 stamps, supplemented by the largest cyanide plant in the colonies, has rendered the present operations successful. The Progress mine, which is one of the largest in the West Coast, has installed a cyanide plant to treat the accumulation of old tailings. Prospecting work is still being vigorously pursued in the Auckland district.

Queensland.—The production of gold during 1900 was 951,065 crude oz. ($13,684,284) against 946,894 crude oz ($13,810,947) in 1899. The value of the increased yield was lessened through the decreased value of the crude gold per oz. The large yield was due to the general application of the cyanide process to the treatment of the mill tailings, and the gold recovered in this manner constituted a little more than one-third of the total yield for 1899. In some of the northern fields the enforced idleness of the mills, from lack of water, prevented many thousands of tons of stone from being treated.

During the year ending May 31, 1900, the Mount Morgan Gold Mining Co., Ltd., treated 239,276 tons of ore, obtaining therefrom 187,352 oz gold, against 204,502 tons of ore and 164,910 oz. gold for the preceding fiscal year. The total receipts were £751,710. Dividends to the amount of £350,000 were declared, leaving a net balance of £27,297. The underground works supplied 20,932 tons of oxidized ore and 59,291 tons of sulphide ore. The surface workings supplied 248,492 tons, of which 159,053 tons were ore and 89,439 tons waste. The average yield of gold per ton was 15·65 dwt. or 0·62 dwt. less than in the previous year. In the chlorination treatment 956 tons of manganese, 901 tons of salt and 3,308 tons of sulphuric acid were consumed. The second section of mundic work is to be completed in the near future. A dam capable of holding 225,000,000 gal., from which it is proposed to furnish the town supply, has also been constructed. No fewer than 2,000 men are employed in the mine and works. The Charters Towers district milled 206,247 tons of ore during 1900, yielding 214,116 oz., and the cyanide works treated 515,206 tons, yielding 237,935 oz., making a total of 452,051 oz., against 512,042 oz. in 1899, a decrease due mainly to the exhaustion of the sands amenable to cyanide treatment. The mills show a decrease of 3,600 tons in ore treated and of 10,657 oz. gold production, while the cyanide works are responsible for a decrease of 178,331

tons of sand treated and of 40,321 oz. gold, against the corresponding amounts for 1899. Despite the decrease in returns, a large amount of development work has been done during the year. The Brilliant and St. George Gold Mining Co. treated 34,800 tons of ore in 1900, yielding 36,721 oz., and paid dividends amounting to £88,200. This company is equipped with six Huntington mills and a 100-ton cyanide plant. Kelly's Queen Block paid dividends of £50,400; Day Dawn Block and Wyndham £49,840. At the Victoria mill of the Waihi Gold Mining Co. 100 new stamps have been erected and the old set of 190 stamps have been altered for wet crushing. Development work has proceeded very satisfactorily during 1900, and it has been proposed to increase the capital of this company to £330,000. The mines of the Gympie district produced 118,037 tons of ore, yielding 91,294 oz. gold, an increase in production over 1899. Dividends were paid amounting to £105,365. Dredging is practically in the experimental stage. Large areas have been taken up for this purpose, and a number of dredges are under construction. On the Burdekin River in the Ravenswood district one dredge has been working, and the results of a "clean-up" are awaited with interest. Should the experiment prove successful, it will be the forerunner of a new and large industry.

South Australia.—The greater part of the yield in 1900 which amounted to 29,397 crude oz. ($531,498) was obtained from the Northern Territory, where the mines are largely in the hands of Chinese. A number of properties, however, have recently been acquired by an English company which has erected the works necessary for proper development. Included in the total of 1,486 men engaged in gold mining in the Northern Territory in 1899 were 1,372 Chinese, of whom about a fourth are physically incapable of doing a fair day's work. In Tarcoola, several veins have been traced from the surface and specimens of rich ore have been obtained from a number of shafts. At Brown's Hill gold has been found in a large ironstone and quartz lode, accompanied by diorite in quartzite country. These discoveries are very important and warrant further exploitation. The occurrence of coarse gold in the lodes renders profitable treatment almost certain. At the Enterprise mine, Earea Dam, about 170 tons of ore were mined, some of which returned about 4 oz. gold per ton.

Tasmania.—The production of gold during 1900 amounted to 80,130 crude oz. ($1,520,867) against 83,992 crude oz. ($1,593,835) in 1899. This production was from quartz milling, cyanide and chlorination and alluvial deposits, and is approximately in the ratio of 33:16:1. The Mount Lyell Mining & Railway Co., in the semester ending September 30, 1900, treated 144,301 tons of ore of an average assay of 2·48% Cu, 1·95 oz. silver and 0·074 oz. gold. The gold production from this source amounted to about 20,000 oz. in 1900. Beaconsfield is the principal gold field and in this district the Tasmania Gold Mining & Quartz Crushing Co. during the fiscal year ending June 30, 1900, produced 30,059 oz., valued at £116,250. The company paid £27,000 in dividends for this time. The Edwards mechanical ore roasting furnace continues to give satisfactory results, 200 tons of ore weekly being roasted in their four furnaces at a labor cost for three men employed equal to 16c. per ton. It is claimed that for an equal amount of fuel consumed the mechanical furnace will roast two

and one-half times as much ore as a hand-worked furnace. The Lefroy field, although at present of small yield, promises to become an important center of gold production, the reefs having been proved to a greater depth. At Mathinna the New Golden Gate mine, the deepest in Tasmania, continues to be a dividend payer. Its main shaft is down 1,430 ft. and the output for the fiscal year ending June 30, 1900, was 19,650 tons of ore treated, yielding 15,920 oz. gold by battery and pyrite concentrate treatment, valued at £59,600; 36,300 tons of sand also were treated by the cyanide process, which yielded 3,409 oz. of gold, valued at £10,200. Dividends paid during the year amounted to £32,800. At Mangana active prospecting has been carried on for some time and some rich ore has been obtained. The western district has produced a small amount of alluvial gold and the large extent of auriferous country north of the Pieman River is very difficult to prospect, being covered by dense vegetation.

Victoria.—The production of gold in 1900 was 807,407 crude oz. ($15,712,140), a slight decrease from that of the preceding year. This State has done considerable to help the mining industry, and during the past three years about £140,000 were expended under the provisions of the Mining Department Act. Mining tracts have been cut through mountainous districts and large areas otherwise difficult of access have been opened up to the prospector. In 1899 the Sandhurst district produced 235,596 oz., the Ballarat district 208,920 oz. and Beechworth 104,278 oz. The amount of gold won by dredging was 17,300 oz., of which 16,500 oz. were from pump-hydraulic sluicing, 200 oz. from bucket dredging and 600 oz. from jet elevating. At January 1, 1900, there were 25 plants at work, and 20 under construction. There were 30,114 men engaged in the search for gold in Victoria at the end of 1899. Of these, approximately, 1,500 were Chinese, but the miners of this race are steadily decreasing in number. Much capital was invested during 1899 in connection with mining enterprises, yet, unfortunately, proper discrimination has been lacking in many instances and a number of companies have been recently wound up as an outcome of insufficient working capital through an overload of paid-up floaters' shares. The department granted more than 1,000 new gold mining leases in 1899 and, in the interest of legitimate mining, every effort was made to prevent speculative shepherding; 964 leases were declared void during the year for non-fulfillment of covenant. The subject of mine ventilation has been taken up by the Government Board and a more rigorous examination of mine inspectors is now called for; two developments of progress that will greatly benefit the industry of gold mining.

Western Australia.—At the present time, there are 18 gold fields in the colony, the most important producers being East Coolgardie, Coolgardie and North Coolgardie, in the eastern district, and Murchison, in the central district. For the past few years Western Australia has held the premier position among the Australasian colonies for its gold production. It is estimated that there are now 21,000 miners actively engaged in the gold fields. The yield during 1900 amounted to 1,580,950 crude oz., valued at $29,233,033, as compared with 1,643,876 crude oz., valued at $30,236,907 in 1899. In a broad sense the year 1900 witnessed the transition from free milling to the treatment of sulphide

or refractory ores. Several processes have been devised to treat the sulphide and telluride ores and reference should be made to the special papers by Alfred James and J. K. Wilson under the section devoted to the progress in the cyanide process during 1900, elsewhere in this volume.

The Lake View Consols, Ltd., reports for the year ending August 31, 1900, profits amounting to £387,718. The balance brought forward from previous years was £230,381 and a dividend of £2 5s. less income tax absorbed £562,500; deducting other expenses the balance for the new year was £4,513. The total production of gold was 157,158 oz. (£608,983) and details of treatment and costs are given in the subjoined table:

SUMMARY OF OPERATIONS AT THE LAKE VIEW CONSOLS, LTD., FOR FISCAL YEAR ENDING AUGUST 31, 1900.

	Battery Process. Ore.	Lixiviation Process. Oxidized Sands.	Filter-press Process. Oxidized Slimes.	Sulphide Ore. Treatment at Mines.	Sulphide Slimes.	Shipped to Smelters.
Tons of material treated	11,944	10,867	35,919	18,014	3.960	3,764
Average yield, per ton..	19 dwt.16gr.	8 dwt. 1 0gr.	7 dwt. 1 gr.	1 oz. 11 dwt. 21 gr.	2 oz. 4 dwt. 13 gr.	25oz 5dwt5g
Gold obtained, oz.....	6,385	4,578	12,662	29,691	8,821	95,093
Average val. of sand...		11 dwt. 2 gr.		1 oz. 19 dwt. 3 gr.		
Average val. of slime..			9 dwt. 5 gr.			
Average val. of residue		2 dwt. 16 gr.	2 dwt. 4 gr.	7 dwt. 6 gr.	4 dwt. 23 gr.	
Extraction, per cent....		75·9	76·5	81	90	
Con. of cyanide per ton.		2·04 lb.	2·20 lb.	6·66 lb.	10·95 lb.	
Cost of treat't, per ton..	10s. 8·996d.	7s. 2,800d.	13s. 4·991d.	Crushing & transit, 9s. 5d. } total Roasting.....17s. 1d } (a) Leach.&filter press.16s. 11d. } 43s. 5d.		

(a) This amount was reduced to 32s. 10d. during the last three months of 1900.

The 50-stamp mill at the mine was rearranged by the London and Hamburg Gold Recovery Co., Ltd., to treat the sulphide ore by the Diehl process and was expected to be in operation before 1901. If satisfactory the Diehl plant will be taken over by the company. The treatment of the sulphide ore at the mines consisted in crushing by Krupp ball mills, roasting in Brown straight-line furnaces, air separation into sand and slimes, lixiviation of the sand in vats, treatment of slimes by agitation and filter-pressing. The furnaces were altered until finally satisfactory, the work of each furnace at the end of the year approximating 30 tons of ore per day per furnace, removing the sulphur to 0·15%. The amount treated per day could be increased to 40 or 45 tons without seriously affecting the roast. The air separators yielded a poor product and the subsequent rate of extraction was greatly retarded by their use. The treatment of the sands in vats was not satisfactory as the presence of 7% CaO in the ore had a tendency to make the material set in the vats which rendered the percolation slow and imperfect. To this cause and to the presence of coarse gold formed in roasting may be attributed the high value of the residues from sand treatment. The time of vat treatment was three weeks, causing the unnecessary consumption of cyanide. Under agitation and filter-pressing with proper separation of sands and slimes, this portion of the process would show a satisfactory extraction. The high values of the residues, 4 dwt. 23 gr. is due to the presence of sand. The proposed Diehl process, which consists of wet stamp-crushing, classification and concentration, reduction of sands to slime in mills and treatment of slimes in agitators with bromo-cyanide solution, followed by filter-pressing, promises very successful results and in the matter of cost it will be

much cheaper than the present process in use at the mine, as the preliminary roasting of the ore with loss of gold in dust will be avoided.*

The report of the Ivanhoe Gold Corporation, Ltd., for the year ending December 31, 1899, showed 59,664 tons milled, of an average tenor of 1 oz. 14·3349 dwt. gold per ton, yielding 104,009 oz. bullion; 37,369 tons of sand yielded 21,796 oz. of bullion at a cost of 5s. 3·287d. per ton treated; 31,685 tons of slimes were passed through four filter-presses, yielding 11,439 oz. at a cost of 6s. 3·229d. per ton treated. The percentage of total extraction, 90·73, was divided into amalgamation, 66·35%; concentrates, 2·07%; sands cyanided, 13·85%; slimes cyanided, 8·46%. The chief factor of loss is the coarse sands, but the addition of a grinding plant will minimize it. During 1899 the Great Boulder Perseverance Gold Mining Co., Ltd., produced 45,283 oz. of gold with a gross profit of £105,531. The average yield, exclusive of tailings, was 1 oz. 12 dwt. per ton. The average yield of tailings per ton was 14 dwt. Mining, milling and general expenses in Australia amounted to £54,752. The Great Boulder Proprietary Gold Mines, Ltd., treated 51,835 tons of ore during 1899, which gave a yield of 83,616 oz. gold, valued at £333,541. The tailings plant began operations in August and 23,707 tons of tailings were treated at a cost of 11s. 9d. per ton, a figure that will admit of decrease. The loss in cyanide was 2·2 lb. per ton and the residues averaged 39 grains gold per ton. The net revenue for the year was £213,436, out of which four dividends of 6d. per share were paid, and of the balance it was proposed to write off £20,000 for depreciation and £20,000 for mine development. An interim report for 1900 shows a net profit of £250,139 subject to revenue tax deduction in England and the new revenue tax in West Australia, each of 5%. The cost of treating the oxidized tailings is given at 10s. per ton and the cost of mining and treating sulphides during January and February, 1901, is estimated by Mr. Jas. Edwards as follows: Stoping, 11s.; milling, 18s.; cyaniding, 10s.; general expenses, 6s.; total, 45s. on a basis of 6,000 tons per month. The output of the Golden Horseshoe Estates, Ltd., for the 10 months ending December 31, 1899, was 85,194 bullion ounces of gold, valued at £335,952. There were stamped 32,695 tons of ore, which yielded 64,055 oz.; 410 tons of concentrates shipped to smelters, yielded 2,604 oz., while the cyanide plant treated 15,408 tons of tailings, yielding 18,535 oz. Total expenses amounted to £88,335 and £225,000 were paid in dividends. The report of the Sons of Gwalia, Ltd., for 1899 shows that the new plant has not yet been completed, and that large sums have been spent in putting the property in order. The old plant produced 18,446 oz. fine gold. Of this 17,092 oz. were produced in the battery from 17,655 tons of ore, 650 oz. from the cyaniding of 257 tons of concentrates, and 704 oz. from 1,500 tons of tailings; 50 stamps are to be added. The British Exploration of Australasia, Ltd., has been formed in the Pilbarra district with an authorized capital of £500,000, of which £400,000, in £1 shares, will be issued. Mr. A. E. Morgans is the managing director in Western Australia and the company was formed primarily to operate gold mines, although copper and tin mines are also included.

* For a discussion of the Diehl process reference should be made to the paper by Alfred James under the section devoted to the progress of the cyanide treatment during 1900, elsewhere in this volume.—EDITOR OF THE MINERAL INDUSTRY.

Progress in Gold Milling during 1900.

By R. H. Richards.

A comparison of plain copper with silver-plated copper amalgamated plates at the Colombian mines, Remedios district, Antioquia, Colombia, is given by E. Halse.* The ore is quartz containing from 1 to 5% of sulphides, chiefly iron pyrites with some galena and blende. The sulphides carry most of the gold and silver values, although some free gold occurs in the ore. From the stamps the pulp passes over an upper amalgamated plate 3 ft. 2·5 in. wide and 6·5 ft. long, followed by a lower plate of the same width but only 1 ft. long; thence over a mercury trap to blanket tables and finally to waste. The concentrates caught on the blanket tables are further concentrated in a narrow chest and on an inclined table; the heads from this treatment have the gold extracted by an arrastra, while the tailings are shipped to England. Mercury is added periodically in the stamp mortar.

The following table shows the comparative results of work extending over considerable periods of time:

Gold-saving Appliance.	Plain Copper Plates.	Upper Plates Silvered, Lower Plain Copper.	Silvered Plates Only. (*a*)
	%	%	%
Mortar	15·46	14·99	20·97
Plates	53·975	66·7625	69·17
Mercury traps	5·74	2·645	1·755
Blankets	12·18	3·9675	1·305
Arrastra	12·645	11·635	6·80
	100·000	100·0000	100·000
Gold caught above the blankets.	75·175	84·3975	91·895

(*a*) These consisted of a lip plate 3 in. long and an apron plate 7 ft. 3 in. long.

The table shows that of the total gold recovered, the silvered plates yielded 15% more than the plain copper and the percentage of gold caught above the blankets was 16·72% greater. The plain copper plates tarnished badly owing to acid water and had to be washed frequently with potassium cyanide solution. The use of silver amalgam, nitric acid or iron riffles to promote electrolytic action did no good. Unslaked lime and lumps of potassium cyanide in the mortars partially remedied the difficulty. Silver-plated plates tarnished not at all and the use of all nostrums was discarded except that of putting 20 to 50 lb. of lime in the mortar daily to counteract the acidity of the water.

Halse considers that there is a greater loss of gold with plain copper plates due: (1) to amalgam passing by the tarnished surface; (2) to amalgam loosened from the plates by the cyanide and lost mechanically; (3) to amalgam lost chemically by the same reagent. He estimates this loss to be at least 5% and possibly 10% of the total gold recovered. The fineness of the bullion was also found to be higher with silver-plated plates.

He considers the proper preparation of the silver-plated plates to be very essential. His method is to scour the plate (previously plated with 1 oz. silver per sq. ft.) with a mixture of wood ashes and fine sand, wash with water, rub in

* A paper read before the Institution of Mining and Metallurgy, Jan. 16, 1901.

mercury with a mixture of sal ammoniac and wood ashes, let stand 12 hours, during which time patches of amalgam appear all over the plates, rub these in with a little more mercury, which concludes the operation. After being put in use no dressing was needed for a while except the rubbing in of a little mercury, but after some months, they required to be washed with a solution of sal ammoniac daily. The ore yields 0·96 to 2·32 oz. bullion per ton; this bullion averages about 600 fine in gold and 350 fine in silver.

*A trolley for gold stamp mills** is a device with a cage and bucket running along a track over the front of the stamps and serving for the handling and transporting of shoes, dies, amalgam, etc., to the clean-up room at the time of clean-up or in making repairs to the battery. Its purpose is to dispense with much of the manual labor.

The mechanical squeezing of amalgam is not practiced to a great extent in the small gold mills of the West, probably because small amounts of amalgam are easier to work by hand, but in the large mill of the Alaska-Treadwell a hydraulic amalgam squeezer† has been introduced. It consists of a ram or piston working in a perforated cylinder in which is placed the canvas sack containing the amalgam. The ram is worked by a water cylinder and piston.

Gold Milling in Georgia.—H. V. Croll‡ relates that the former method of hydraulicking the surface gravel and sluicing it to the mill bin, has been replaced, since the mining has reached the sulphuret-bearing zone at the Dahlonega mine, by open-cut mining and by modern California stamp mill with amalgamated plates and vanners, the vanner concentrates being worked by chlorination. He gives the main adjustments there adopted.

The method of milling used at the Haile gold mines, North Carolina, is described by Arthur Lakes.§ The ore is crushed at the mine and is fed to 60 stamps, 30 on a side, 750 lb. weight, dropping 90 times per minute, crushing from 2 to 2·5 tons per stamp per 24 hours. They are fed by Hendy feeders and discharge through 35-mesh brass wire cloth over 8 ft. of silver-plated copper plates coated with mercury. The plates are attached to the battery to gain the advantage of the tremor. Cyanide is used for cleaning plates. Sodium phosphate is used in the battery to keep the quicksilver clean and bright. Each battery is provided with an impact plate to retard the velocity of the pulp and increase amalgamation. There are four plates to each battery, 50 in. long×26 in. wide, so that when the upper plate becomes hard and unfit for amalgamation, it is cleaned of amalgam and changed with the lower plate. By this rotation, each plate serves periodically in the first place. Riffles are used for mercury traps. The inside plates are cleaned every 24 hours, while the regular clean-up comes once a month.

The quicksilver consumed is 0·35 oz. per ton; the wear of shoes and dies is 0·5 lb. per ton. The tailings from the amalgamated plates are treated by 20 Embrey vanners, 4 Triumphs and 5 Wilfley tables. The Embrey and Triumph vanners make 192 to 210 end shakes of 0·75 in. per minute, have an inclination of from 3 to 4 in. in 12 ft. and travel 5 ft. per minute. The five Wilfley tables make

* *Engineering and Mining Journal*, April 14, 1900.
† *Ibid.*, April 28, 1900; Jan. 19, 1901.
‡ *Mining and Scientific Press*, Feb. 3, 1900.
§ *Mines and Minerals*, October, 1900.

240 vibrations per minute. No comparison is given between Embrey, Triumph and Wilfley tables. The concentrates assay from $25 to $35 per ton.

*The Ymir Mine and its Mill Practice** is described by S. S. Fowler as follows: The mine yields smelting ore, and mill stuff. The latter is crushed by a Gates breaker and stamped in a 40-stamp mill, the stamps weighing 850 lb., dropping 6·5 in. from 96 to 102 times per minute, with an average height of discharge of 7 in. They crush a little over 100 tons per day through a No. 9 diagonal slot screen. One inside plate accumulates 40% of the gold. The first 2 ft. of the apron plate catch 80% of the plate gold; the last 10 ft. catch an amalgam with a very much higher percentage of silver in it than the amalgam from the first 2 ft. The pulp from the plates is classified by cone classifiers with four spigots each before going to the Frue vanners.

The Custom Stamp Mill of the Ottawa Gold Milling and Mining Co., at Keewatin, Ontario, is described by F. H. Probert, in a paper on the Lake of the Woods district.† From this the following notes are taken: After passing the breaker, the ore goes over an inclined 1-in. mesh gravel screen, the oversize of which is crushed by rolls and returned to the screen; the undersize is sent through a Snyder sampler and then stamped. Double discharge mortars are used. The gyrating amalgamated plates and vanners formerly used have been replaced by stationary plates and Frue vanners, owing to numerous breaks and unsatisfactory results.

The Montana and Denver Reduction Co.'s Mill, Bearmouth, Mont,‡ is a custom mill. The ore comes to receiving bins and goes to a 9×15-in. Blake breaker, thence by elevator to rolls, again by elevator to Vezin sampler, which takes out one-twentieth, and finally to the stamp bins. The ore is then pulverized by a 20-stamp mill and where it is oxidized a 40-mesh screen is used while a 30-mesh is used for sulphides. The tailings from the amalgamated plates go to a 4-spigot classifier which makes four spigot products to four double deck Wilfley tables. The lower decks re-treat the tailings of the upper decks. The tailings of these tables go to cyanide works. The fine slimes (overflow of the classifier) are waste or are caught on blanket tables.

A fair profit can be made on ore worth $15 per ton which heretofore has been sent to the waste dump. The mill requires an 80-H.P. engine and two 50-H.P. boilers and is lighted by incandescent lamps from a small 100-lamp dynamo. The capacity of the mill is 60 tons in 24 hours.

The Evolution of the 300-stamp Alaska-Treadwell Mill, on Douglas Island, Alaska, is discussed by Henry Watson.§ Owing to favorable location and great mechanical skill, it is possible to work at a profit an ore averaging less than $3 per ton. The old mill of 240 stamps required 22 employees, the new mill of 300 stamps requires only 23 employees. The old stamps weighed 850 lb., dropped 6 in. 98 times per minute; the new weigh 1,080 lb., fall 7 in. 101 times per minute. The crushing capacity of the 300-stamp mill is 90% greater than the 240-stamp mill.

* *Journal of Canadian Mining Institute*, Vol. III., 1900, p. 3.

† A paper read before the Institution of Mining and Metallurgy, March 28, 1900.

‡ F. D. Smith, *Engineering and Mining Journal*, March 24, 1900.

§ *Mining and Scientific Press*, June 16, 1900.

The Bryan Mill.—E. A. H. Tays* gives results of actual work with a Bryan mill and with stamps in crushing and amalgamating the same ore, and he concludes: The first cost and running cost of a Bryan mill is about the same as that of a 5-stamp battery, but it can be got into running order in much less time. A 4-ft. Bryan mill crushes as much as two 5-stamp batteries. As to amalgamation of gold, the total yield was about the same in both cases, but much more gold was caught in the stamp mortars than in the Bryan mill. The wear of iron in the Bryan mill in 156 days was 2,904 lb., that of two batteries (10 stamps) was 3,400 lb. of iron; but owing to the higher price of materials the cost for wear of iron and screens for the Bryan mill was 17·5c. per ton, while that for stamps was 6c. per ton. A. H. P. Wynne, in discussing this paper, states that while the capacity of a 4-ft. Bryan mill on soft ores might equal that of two batteries, it would not be more than that of one battery on hard quartz.

Frue Vanners.—A. R. Canning,† in a paper on the Lucknow, New South Wales, gold fields, calls attention to the good work done by Frue vanners with belts traveling 60 in. per minute and with from 150 to 200 vibrations per minute (slope not given) in concentrating very rich gold ores.

Power and Water Consumption in California Mills.—Some interesting figures on this subject are given by A. W. Warwick.‡ He finds at the Old Dominion mill, San Bernardino, Cal., which is a 5-stamp gold mill run by steam, the coal is 8·33 lb. and the water is 7·5 gal. per horse-power hour. The mill uses 15 H.P. At the Matterhorn 10-stamp mill in the southeast corner of the Mojave desert he found an oil engine supplying 30·6 indicated horse power and consuming 0·085 gal. oil per horse-power hour. This would cost 1·74c. At the latter mill he found the water used in the mill averaged 90 gal. per stamp per hour. By unwatering the sand by an unwatering box and spitzkasten and using the water over and over, the amount of fresh water supplied to the mill was only 18·95 gal. per stamp per hour.

The mechanical preparation and chemical treatment of gold ores for the last ten years has been reviewed by C. Blömeke.§ The article contains a valuable list of references and a résumé of their contents. The article is not adapted to the making of an abstract.

The Stamp-Milling of Free Gold Ores.—In a paper read at the Technical Society of the Pacific Coast, September 7, 1900, Dana Harnum‖ gives his views, going well into details. He prefers two breakers, coarse and fine. He advocates the use of punched tin-plate screens. He considers the plain splash board to be the best of all distributors. He believes in steep apron plates, 2·5-in. grade per ft. with a 0·5-in. step drop every 2 ft. He trusts to scrubbing alone for cleaning his plates, without the use of cyanide. Double drain boxes are preferred for mercury traps. The sudden rise in temperature of from 20 to 30°F. which sloughs off so much amalgam should be avoided and care should be taken to keep the water as nearly 65°F. as possible throughout the year. He criticises the

* *Transactions of the American Institute of Mining Engineers*, Vol. XXIX., 1899, pp. 776, 1054.
† *Transactions of the Institution of Mining and Metallurgy*, Vol. VII., 1899, p. 256.
‡ *Engineering and Mining Journal*, May 5, 1900.
§ *Berg- und Hüttenmännische Zeitung*, May 18 and 25, June 1 and 8, 1900.
‖ *Mining and Scientific Press*, Dec. 1, 1900.

belt vanners because they require close watching and thinks the Wilfley tables may prove to be better. Well lighted and heated mills are necessary to secure best results.

Cost per ton of Dry Crushing at Mt. Morgan Gold Mine, Australia, as given by N. F. White,* is summarized in the subjoined table:

Description.	First Arrangement, Crusher, Dryer & 4 sets of Rolls.	Second Arrangement. 2 Crushers, 2 Dryers and 8 sets of Rolls.	Arrangement during twelve months' run ending May 31, 1899. New West Works, 4 Crushers, 4 Dryers, and 16 No. 5 Krupp Ball Mills, crushing 130,776 tons.					
			Stone Breakers.	Dryers & Elevators	Ball Mills.	Engines.	Boilers.	Totals.
Running Expenses:	s. d.	s. d.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.
Wages	2 6·40	2 6·20	3·420	2·370	2·790	1·850	1·604	12·034
Stores	0 2·80	0 3·90	0·446	0·620	0·904	0·486	0·310	2·766
General expenses	0 1·18	0 0·57	0·066	0·036	0·066	0·027	0·028	0·223
Electric light	0 1·43	0 0·59	0·035	0·125	0·069	0·068	0·035	0·332
Cartage	0 2·30			0·106	0·003		0·126	0·235
Inclined tram				0·517			0·800	1·317
Firewood	1 2·50	2 0·50		3·979			5·559	9·538
Coal				1·150			2·667	3·817
Water supply	0 0·57	0 0·52					0·068	0·068
Totals	4 5·18	5 0·28	3·967	8·903	3·832	2·431	11·197	30·330
Maintenance (repairs):								
Wages	0 3·52	0 5·20	0·277	0·475	1·190	0·340	1·043	3·325
Stores	0 10·67	0 10·80	0·242	0·228	9·750	0·108	0·165	10·493
Cartage			0·002	0·007	0·004		0·025	0·038
Mechanics' work	0 6·28	0 5·21	0·183	1·527	0·755	0·044	0·397	2·906
Timber	0 0·22	0 0·18		0·013	0·002			0·015
Totals	1 8·69	1 9·39	0·704	2·250	11·701	0·492	1·630	16·777
Grand totals	6 1·87	6 9·67	4·671	11·153	15·533	2·923	12·827	*a* 47·107

(*a*) 3 s. 11·107 d.

Gold Dredging.

Three good articles on Gold Dredging have appeared. C. C. Longridge† has treated the subject in full without confining himself to any one locality. P. G. Morgan‡ has given a good account of the history and present practice in New Zealand. F. Powell§ has described the practice on the Snake River, Idaho. It has not been considered wise to give abstracts of these here as it would lead to a duplication in part of the article of A. Grothe on "Gold Dredging in the United States" in The Mineral Industry, Vol. VIII., 1900.

The past year has shown a considerable advance in the dredging of gold in the United States. This is especially true in California, where increased activity has been shown in several counties.

A Hammond gold dredge‖ for working the beach at Cape Nome, Alaska, is mounted on rollers working on the principle of casters and is adjustable with respect to height. It is intended to work into the water to a depth of 10 or 12 ft. and to be moved about at will.

Later reports claim that dredging at Nome is unsuccessful owing to the heavy surf.

* *Transactions of the Australasian Institute of Mining Engineers*. Vol. VI., 1900.
† *Engineering*, Vol. LXVII., 1899, pp. 503, 535, 642, 840; Vol. LXVIII., 1899, pp. 34, 192.
‡ *Engineering and Mining Journal*, Aug. 4, 11 and 18, 1900.
§ *Ibid.*, Oct. 6, 1900. ‖ *Ibid.*, May 26, 1900.

The work of some New Zealand dredges is summarized by Mr. J. P. Smith* in the following table:

Dredge.	Capacity of Buckets, in cubic feet.	Rate of Discharge per minute.	Diameter of Pump, in inches.	Capacity of Pump, in gallons, per minute. (*f*)	Width of Tables, in feet.	Material lifted per minute, in cubic yards.	Material passed over Tables per minute, in cubic feet. (*g*)	Material passed over Tables per foot of width per minute, in cubic inches.	Water passed over tables per minute per foot of spread. (*h*)		Proportion of Sand to Water.
									Gallons.	Cubic Inches.	
Fraser's Flat	7·00	10	12	2,300	21	2·60	35·0	2,800	98	27,168	(*a*) 1 to 9·43
Olrig.....	4·75	10	10	1,600	18	1·76	8·0	768	80	22,180	(*b*) 1 to 28·80
Leviathan	4·75	10	15	3,800	81	1·76	31·6	674	42	11,645	(*c*) 1 to 17·20
Waimumu (*i*)	4·50	12	12	2,300	28	2·00	9·0	555	74	20,519	(*d*) 1 to 37·00
Mokoia and Butler Junction	5·00	12	12	2,300	15	2·20	10·0	1,152	138	38,270	(*e*) 1 to 33·00
Ordinary quartz-mill practice (*k*).....								36	3·5	970	1 to 27·00

(*a*) Fine material. Estimated that one-half of the quantity lifted will pass through the screens onto the tables. (*b*) Manuherikia, ordinary river drift. (*c*) Littoral deposit of shingle and black sand. Estimated that two-thirds of material lifted will pass over the tables. (*d*) Before alterations; valley deposit. (*e*) River gravels. (*f*) Lifting capacity based on Tangye Bros.' calculations. (*g*) In dredging ordinary river gravel, quantity estimated at one-sixth of total lifted; based on cradle trials of different gravels, hopper having 0·3125-in. perforations. (*h*) 90% of the water lifted is presumed to pass over the tables, the balance leaving the screen with the coarse material. (*i*) Waimumu drift is a valley deposit; quantity passing over tables very low; estimated at from 0·25 to 0·20% of quantity lifted with this dredge. (*k*) In battery practice, Rose gives water used per stamp as 1·75 gal. in Colorado, 2·50 in California and 5·50 gal. in South Africa. Figures in table based on 3·50 gal. per minute and crushing power of one stamp at 2 tons in 24 hours.

Among the desired improvements for better results in gold dredging are: a perfect distributor; an increased width of table, especially for the treatment of gravel that contains very fine or scaly gold; a design of dredge that will allow the stripping and removal of the overlying layer of tenacious clay without washing it through the screens; the construction of self-washing mattes for washing beach deposits; the prevention of the dredge material of beach deposits from running back into the dredging basin in the form of a quicksand.

Hydraulicking.

Hobson's steel sluice riffle† consists of smooth steel bars 1·5 in. square and 6 ft. long mounted on top of planks 1·5 in. thick and 6·5 in. wide set edgewise and longitudinally in the sluice. The riffles are spaced 1 in. apart by cleats placed between them at intervals. One hundred feet in length of steel riffles are considered better as a means of recovering gold than 1,000 ft. of ordinary wooden sluice or rock riffles.

George H. Evans† gives a summary of important points to be considered in hydraulicking.

* *The Mines Statement of New Zealand*, 1900.

† *Engineering and Mining Journal*, May 12, 1900.

‡ *Mines and Minerals*, December, 1900.

The Present Development of the Barrel Chlorination Process.

By John E. Rothwell.

In The Mineral Industry, Vols. I. and V., I described the chlorination process as it had then been developed in large American works. The present supplementary article brings the practice to date and adds to the general literature of the subject, a description of those methods employed to increase the efficiency and economy of the chlorination process which have placed it on a firmer basis as one of the standard means for the extraction of gold from its ores.

Several large works have been built and put in operation since 1896, the tendency being to establish plants of large capacities, centrally located to treat the ore from a number of properties or from a district and thus save the individual miner or mining company the expense of erecting a costly plant, by providing for him a place at which he can market his output of all grades and receive a fair value for it.

Competitive plants are built where the district is favorable, and as a consequence the best metallurgical practice is necessary to make profits for the mining company. This paper is therefore chiefly in the line of a works to purchase and treat ores on this principle.

Sampling and Purchase of Ores.—At the custom mills treating the ores of the Cripple Creek district, Colorado, the ore is purchased from the miner on a basis of treatment charge which varies according to the assay value of the ore, paying $20 an ounce for all gold, and on the basis of New York quotations for all silver over 3 oz. per ton. The schedule of rates varies from time to time, but the following was in force at the end of 1900, these charges being for ore delivered at the works:

Tenor in Gold.	Charge Per Ton.
Between 0·75 oz. and less.....	$5·50
Between 0·75 oz. and less 1 oz....	6·50
Between 1 oz. and less 1·25 oz..	7·25
Between 1·25 oz. and less 1·5 oz..	8·00
Between 1·5 oz. and less 2 oz.....	8·50
Between 2 oz. and less 3 oz.....	9·00
Between 3 oz. and less.....	9·50

In the last custom mill which I designed, erected and put in operation, the sampling works received the ore direct from the railroad cars in which it was shipped from the mine. These cars were stored on a track above the sampling department, and when a certain lot was ready to be sampled the cars were run by gravity to a double set of track scales, and each car weighed, unloaded and then weighed light, thus giving an exact net weight. The beams of the scales were self-registering so that mistakes in weight were practically impossible. The ore as unloaded from the car, passed over a grizzly with 1-in. spaces, and the oversize went direct to a 10×20-in. Blake breaker, then to a set of 16×36-in. belt driven, crushing rolls running at a speed of 60 R.P.M. and set about 0·25 in. apart. These reduced it to a product of which the largest pieces did not exceed a cube of 0·75-in. edge. From the rolls, the ore was elevated to a large Vezin automatic sampler, cutting twice in a revolution and making 48 R.P.M., or 96

cuts per minute, which gave a sample consisting of one-quarter of the whole. This portion then passed through a revolving cylinder 24-in. diameter and 48 in. long, set at an inclination of 10 in. and revolving 30 R.P.M., the interior having a series of baffle plates that mixed the sample thoroughly and delivered it to a second and smaller Vezin sampler which cut out one-quarter of the first sample, thus delivering an amount equal to 6·25% of the whole lot. This accumulated in a sheet iron hopper under the last sampler until the sampling of the lot was finished when it was taken to the plate room and coned and quartered to about 400 lb. This amount was then recrushed in small rolls, in the plate room, to about a 3-mesh product, coned and quartered to about 10 lb., and this ground in a sample grinder to about 150-mesh, and cut down to about 2 lb., which is passed through a 200-mesh screen (*i.e.,* 40,000 holes per sq. in.) and subdivided into four samples for assay, *viz.,* the ore seller's sample, the mill sample, the umpire sample, and one extra sample reserved for use in case of accident to the others. The 400-lb. sample, and in some cases the whole of the 6·25% was held till the lot it represents has been settled for, so that in the event of a disagreement in the assays of the ore seller and the mill company, a resample can be made, in which case it is thoroughly mixed and again coned and quartered to the final sample. A settlement is made only when the samples assayed come within 0·04 oz., when it is usual for the mills to split, but in case of a greater difference or some other cause, and a resample is not desired, the umpire sample is sent to a third and disinterested assayer, and should his result come between that of the ore seller and the mill, it is used as a basis of settlement. Should it be above or below both assays, the nearest is taken as a basis or a resample made.

The ore rejected by the automatic samplers passed to an elevator, then to a belt conveyor, from which it was discharged to any one of a line of storage bins, or to one of two storage beds on which it could be distributed and bedded to a uniform mixture. The different lots of ore, except those on the beds, are held separate and intact in most mills until settled for by the mill company. From the storage bins, the ore is fed and carried automatically on a belt conveyor to a centrally located elevator that delivered it to the storage hoppers over the drying cylinders, where it was dried and passed to the fine crushing rolls and reduced to the fineness of product necessary for subsequent treatment.

Crushing Department.—For the preparation of the ore for the final treatment, rolls have not been superseded to any extent by any of the other patented pulverizers or mills that have come into existence during the last few years. The method of operating rolls is a matter of considerable difference of opinion among engineers and mill men. For myself, I have no reason to change my opinion, expressed in the article in THE MINERAL INDUSTRY, Vol. V., *viz.,* that the most economical roll is the low-speed machine. The present tendency is to make the machine very much heavier, stronger and more substantial in every way and to support it on a solid foundation. The unit system of crushing machinery is also a new feature in recent work, at the same time maintaining the gradual reduction system, as I noted in THE MINERAL INDUSTRY, Vol. V. The system is applicable to the larger capacities of 100 tons per day and over. The arrangement of the units permits of any one being stopped for repair

without interfering in any way with the operation of the others. Each unit comprises a set of rolls, elevator and sizing screens, all driven from a counter-shaft, which is driven from the main line shaft through a friction clutch or other arrangement permitting independent stopping and starting.

The elevation and plan, Fig. 1, shows the arrangement of a single unit with a capacity for crushing 50 tons in 24 hours from a coarse product of about 3-mesh or 0·25-in. cubes to a finished product that passes a wire screen of 12-mesh,

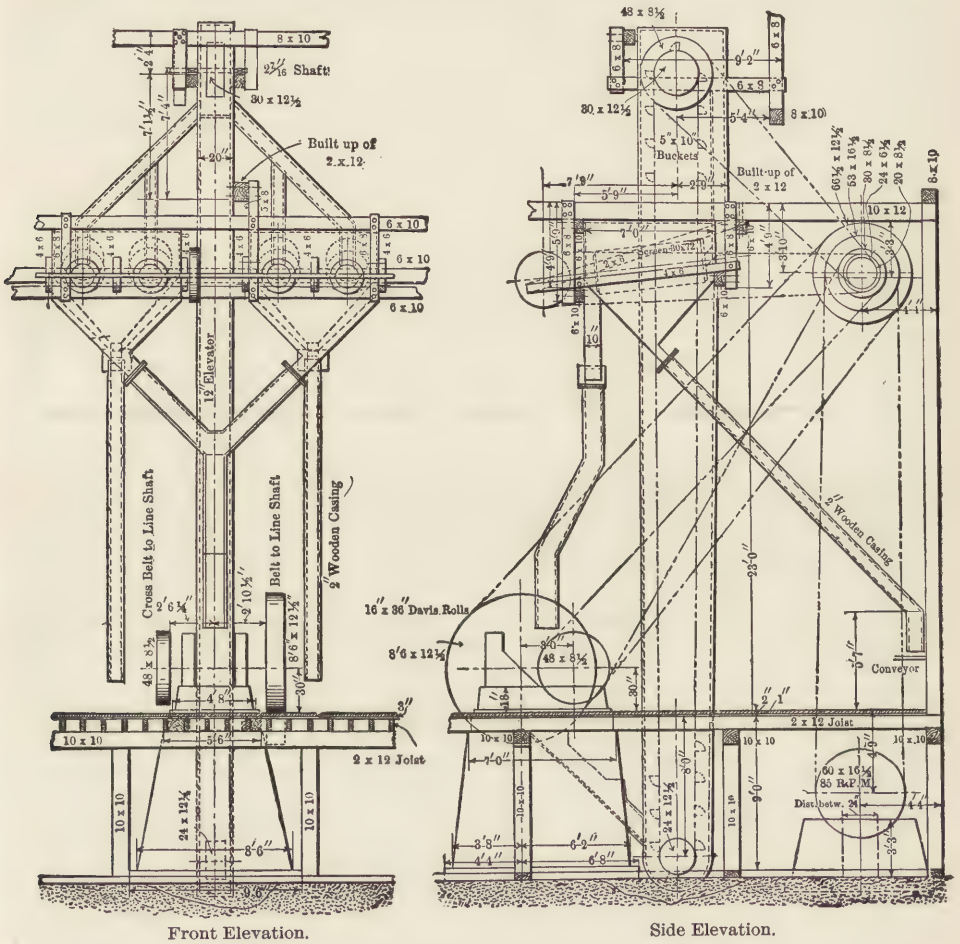


FIG. 1.—DRY-CRUSHING PLANT OF 50 TONS DAILY CAPACITY.

using No. 19 B.W.G. wire. The arrangement permits the main line shaft to be kept low down on substantial foundations, and short counter shafts that alone have to be kept in line with the unit of machinery they have to drive. The rolls are placed on stone piers with concrete base well cemented together. Instead of placing the elevator in a pit as is the usual custom the whole is kept above the surface of the ground, which admits of plenty of light and room for the close supervision of the machinery.

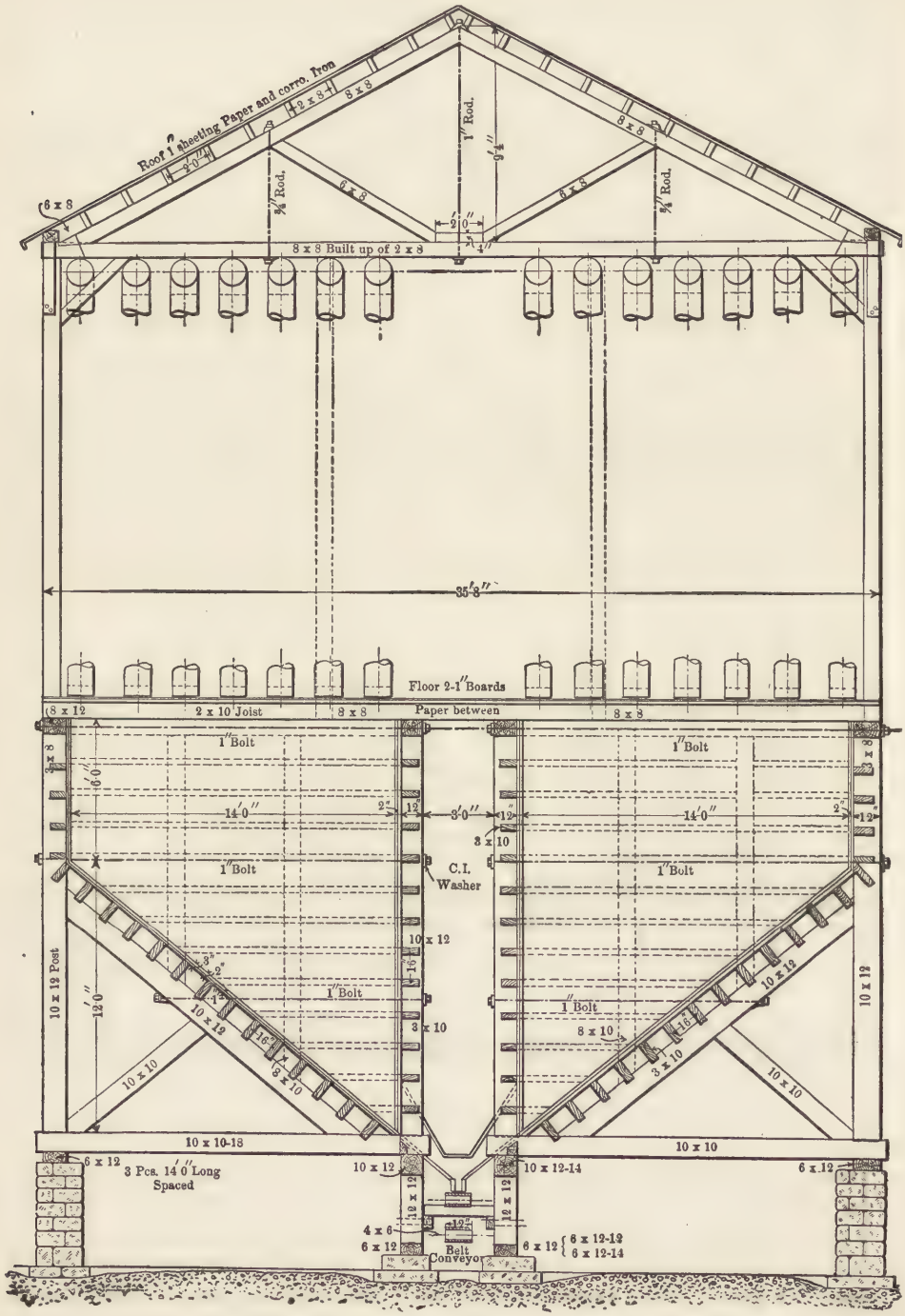


FIG. 2.—BAG ARRANGEMENT FOR THE COLLECTION OF DUST.

Dust Collectors.—The dust, the usual bugbear and source of loss in all dry crushing mills, is collected in several ways at the different mills, the bag-room in some of its forms being the fundamental principle. In some mills the collected dust is not treated at all, but shipped to a smelter where it is briquetted and smelted, while at other mills it is mixed with the finished pulp and passed with it through the treatment. Fig. 2 is an arrangement used in a recent mill in which the dust is exhausted from the rolls, elevators and screen casings, by a large exhaust fan and blown into a series of cotton bags located above the pulp ore storage bins, the arrangement of which permits of the cleaning of any line of bags without interfering with the others, thus affording a continuous operation of the collecting system.

A machine largely used in flour mills is now being used in some of the new mills, in which a number of small bags are carried radially on a horizontal cylinder and arranged so as to collect the dust blown into it, discharging it automatically to a screw conveyor which in turn carries it to the main pulp elevator or chute leading to the storage bins.

Systems of hopper-bottomed storage bins in flues are also used at some mills, into which the dust is blown and settled. These, however, involve labor to empty, require attention, besides giving the dust in quantity at a single time which causes difficulties in the after treatment. It is my belief that the best method is to mix the dust with the pulp continuously, treating the mixture in the usual manner. The object of some of the mills in separating and shipping the dust is to get over the difficulty of treating it separately, as well as to remove it, its absence tending to give a better leaching product, and in consequence, a greater capacity to the plant.

Roasting.—For the roasting of the crushed pulp before chlorination the mechanical rabbled hearth furnaces are used almost entirely. Revolving cylinder furnaces of the Oxland, Howell, Brückner and Argall types are not used to any extent in the works recently constructed, the objection to this style of furnace being the enormous dust separation and consequent difficulty in treating it. None of the shaft furnaces of the Richard type has been installed in America, although it is reported to give excellent results in Australia, Queensland and West Australia. The hearth furnaces principally used in America are the Pearce, Ropp, Brown, Holthoff-Wethey and Jackling, the last two being recent additions to the field.

It has been the practice in treating Cripple Creek ores to arrange the mixture from the different mines so that the sulphur content will be close to 1·5% in order to get a maximum capacity to the furnace. This sulphur has to be reduced practically to zero in order to get the best extraction. The sulphur in the roasted ore is determined in both the soluble and the insoluble states—the soluble being the sulphur in the sulphates soluble in hot water, and the insoluble the sulphur in sulphides or other forms insoluble in hot water. When a furnace is in good working condition and the pulp uniform in its sulphur content, the sulphur left in the roasted ore should not exceed 0·1%, of which for the best work the insoluble should not exceed 0·03%.

For the roasting of Cripple Creek ores, coal and oil (residuum) together are

most generally used. The coal in the first fire-boxes or colder portion of the hearth, and the oil for the finish. The amount of fuel used in the different styles of furnaces varies slightly, a fair average consumption being from 90 to 100 lb. of coal, and from 14 to 18 gal. of oil per ton of ore roasted. The coal used is the semi-bituminous variety of the Colorado coal fields and costs for run of mine from $1·65 to $2·25 per ton delivered at the works. The oil is from the refineries at Florence, Colo., and costs from 75c. to $1·10 per bbl. of 42 gal. Producer gas plants are being installed at some of the mills, but have not been in operation long enough to give reliable figures on which to base a difference of cost. Where it has been used the results are reported to be satisfactory and favorable.

The temperatures at which the roasting is done vary from the cold ore, to about 700°F. at the first fire-box, one-third the distance on the hearth, and from this it increases to 1,100°F. at two-thirds, the finishing heat being between 1,500 and 1,600°F. The usual time required to pass the ore through the furnace varies from 3·5 to 5 hours, depending on the amount fed in. The gold losses by volatilization that is so much feared and discussed by metallurgists not familiar with recent practice is practically *nil* in the Cripple Creek telluride ores, all losses being mechanical.

The ore after being roasted is automatically cooled, which does away with the large area formerly required on which to spread the hot pulp; the labor cost to handle and spread it is also abolished. A number of arrangements have been devised for the cooling. In some cases the return mechanism of the straight line hearth furnaces is used to move the pulp back along a hearth of light sheet iron open to the air, located either above or below the roasting hearth, as the construction of each furnace permits. This method has proven satisfactory, but involves the use of double rabble arms, which are heated in the roasting hearths and drawn through the hot pulp. A form of cooling hearth which I designed has an annular sheet iron hearth arranged with suitable expansion joints, on which the hot pulp is distributed and plowed around, being turned over eight times in a revolution, and uniformly pushed ahead by the rabble plates operated from a central hub, on a pivot, to which the driving mechanism is attached. Three of these are now in operation at the mill of the Union Gold Extraction Co., at Florence, Colo., and cool the roasted ores from 6 forty-foot Pearce turret furnaces. In estimating the area required to cool ore on a hearth, it has been found that an area of 6 sq. ft. of hearth surface is ample for 1 ton in 24 hours, the ore being delivered to it at a temperature of about 800°F. and leaving it at about 100°F.

Hearths with a water jacket have been used in several places, but no material advantage seems to be gained thereby. They are more expensive to construct, there is danger of leaking, and they require water, which has to be pumped back and cooled, unless a constant water supply is available and the water allowed to waste.

At the cyanide plant at Cyanide, Argall's patent revolving cylinder cooler is used. This is a multi-tubular cylinder revolving on tires, and arranged for the water cooling of the tubes, through which the hot ore is passed.

At the Colorado & Philadelphia Reduction Co. plant, the cooler consists of a sheet iron tower, divided in the interior with a series of sheet iron shelves, over which the hot ore passes in a thin sheet, while cold air is forced through the interstitial spaces around the shelves and carries off the heat. This apparatus has been in operation for a number of years and is apparently satisfactory. Its first cost of installation is quite large.

A water-jacketed cooler invented by me* is described in the *Engineering and Mining Journal,* July 29, 1899. It consists of a water-tight steel shell of any shape to suit conditions, with a series of tubes in it, the same as the flues of a vertical boiler; above the tubes a storage hopper, and below a mechanical arrangement like an ore feeder. In operation the hot ore settles slowly through the tubes, the feeder arrangement being set to take the pulp away as fast as it comes from the furnace. Water is circulated through the shell outside the tubes and removes the heat. This device has proved very effective. It is not expensive and occupies very little room. In one case the apparatus was 11 ft. high, with a base 6-ft. square, and had a capacity of 30 tons per 24 hours. No dust was made and the pulp was delivered dry. The water was circulated through tanks and cooled and used again.

Another cooling device put in use at the El Paso Reduction Co.'s works at Florence† consists of a number of cars of about 1-ton capacity, arranged with coils of pipe, through which water is circulated and the heat extracted, the cars then being elevated and emptied into the charging hoppers over the chlorinating barrels.

Chlorination.—In the matter of apparatus used in chlorination, there have been no changes, except in general increase in size and capacity. The roasted ore is weighed and placed in the charging hoppers, thus getting an accurate weight treated. The capacity of the chlorination barrels has been increased to as high as 18 tons per charge, in barrels 6 ft. 6 in. diameter by 15 ft. long revolved on two encircling tires.

I have designed and operated very satisfactorily barrels of a capacity of 12·5 tons of ore (see Fig. 3 for dimensions and general construction). The barrel filters employed in the barrels have remained the same in principle, although the framing and the material used for the filtering medium have been slightly changed. For this a finely perforated sheet of lead of 4 or 6 lb. weight per sq. ft. is laid on plates of lead 0·375 in. to 0·75 in. thick, perforated with 0·375-in. holes, about 0·75-in. centers, in some cases the plates being corrugated between the holes. These plates are supported on a wooden framework as originally planned. The perforations in the lighter sheet vary in dimension at the different mills. They are usually round and about 0·375-in. centers, and nominally about 20-mesh, or 69 mm. These sheets are usually punched by hand at the mill at which they are used. The life of the sheets varies from 6 to 60 charges, depending largely on the care with which they are put in and the character of the sheet lead used. For this purpose "chemical sheet lead" alone should be employed. The heavy plates will last for an indefinite length of time unless the wood framework supporting them gives way. The wooden frame has a life of

* United States Patent No. 625,608, May 23, 1899. † United States Patent No. 672,373, April 16, 1901.

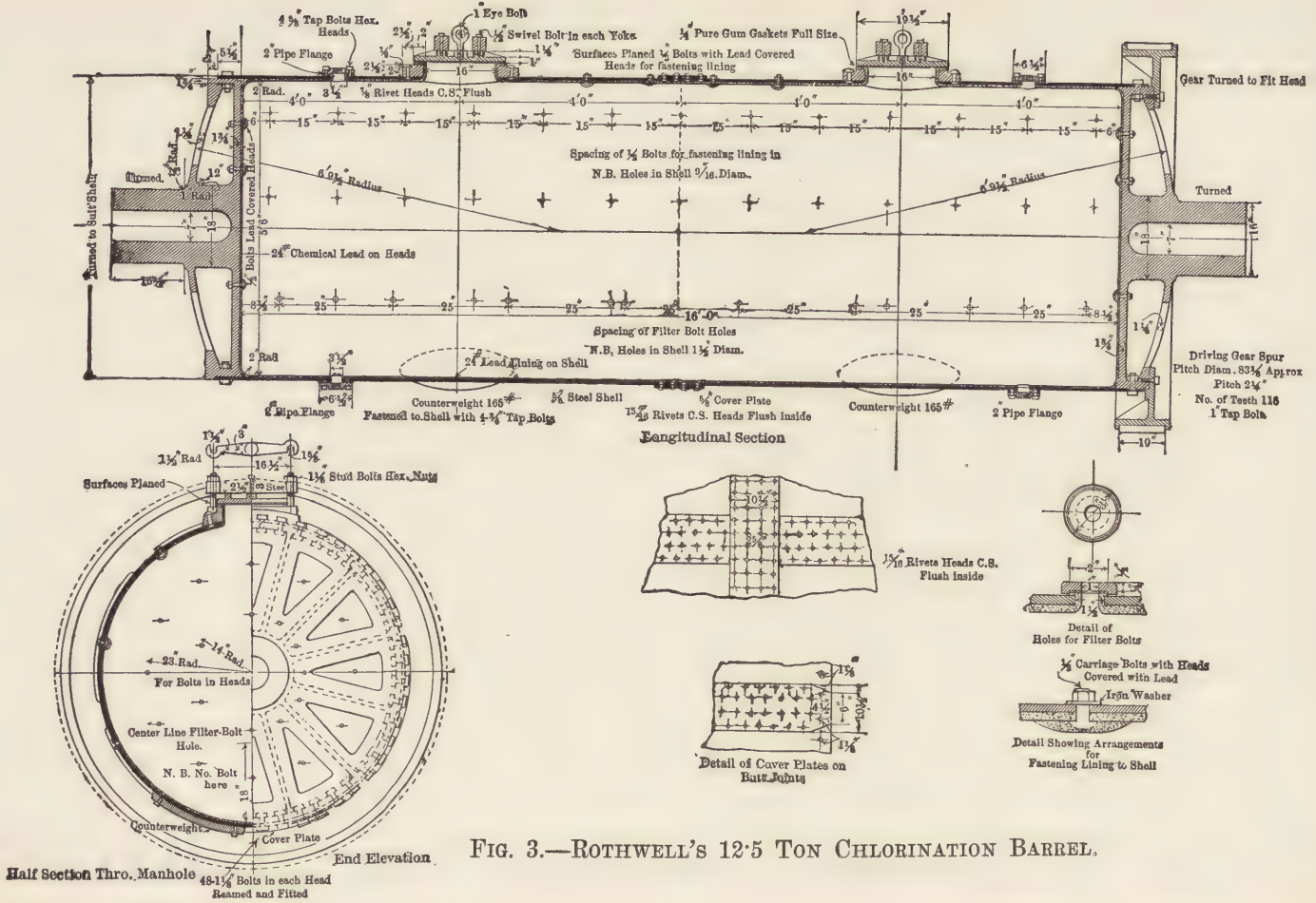


FIG. 3.—ROTHWELL'S 12·5 TON CHLORINATION BARREL.

about three months' constant usage, after which it is so weakened that it is advisable to renew it. The frames employed to hold the lead in place wear out rapidly, often having to be renewed every two or three weeks. In the 12·5-ton barrel, the filter has an area of 4×16 ft. The full charge of ore lies to a depth of 38 in. on the filter, and can be leached when everything is in good condition in from 75 to 90 minutes. The average time over a month's run or more is about 150 minutes, the water pressure used varying from 10 to 40 lb. per sq. in.

The gold solution from the barrels passes first to a small tank containing a gravel filter which removes any sand that may have passed the barrel filter;

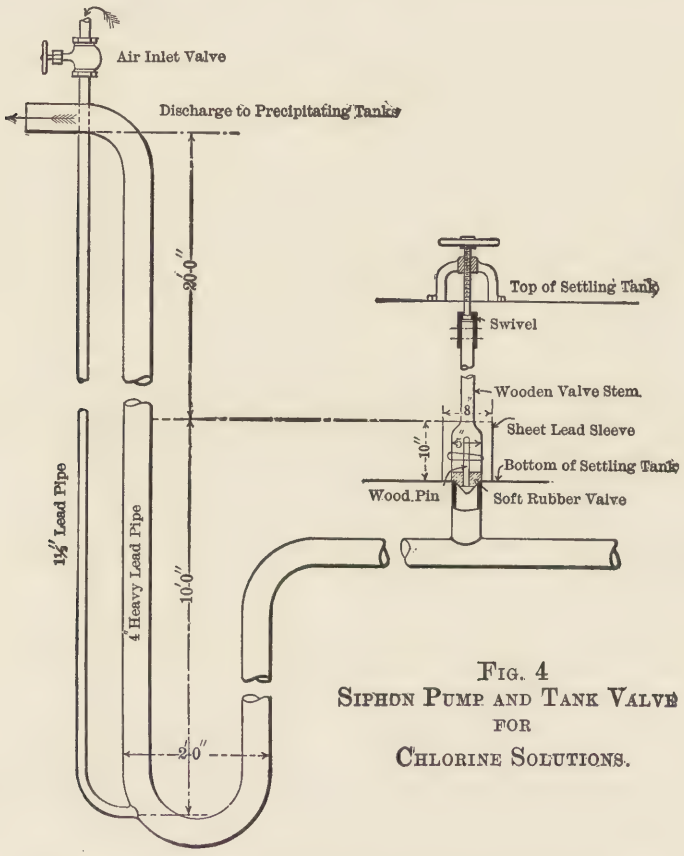


FIG. 4
SIPHON PUMP AND TANK VALVE
FOR
CHLORINE SOLUTIONS.

from this the solution flows to the settling tanks. At the present time I build the settling tanks of large capacity, having enough of them so that at least eight hours shall elapse from the time one tank is filled until it is required again. The tanks are shallow in order to give a large area and promote rapid settling. From these tanks the solution goes direct to the precipitating tanks and in order not to get any fine slimes from them, the solution is drawn from a level 10 in. above the bottom of the tank.

The solutions are transferred from the settling tanks to the precipitating tanks by means of an inverted siphon after the principle of the Pohlé air-lift pumps,

using air under pressure to force it up the outlet pipe. Fig. 4 gives a plan of this apparatus, which for the elevating of solutions is much superior to the Montejus system employed in some works. The arrangement is similar to that which was suggested by the late C. A. Stetefeldt, in an article in the *Engineering and Mining Journal,* December 28, 1889, a description of which did not come to my notice until quite recently. The siphon is connected with a line of pipe along the bottom of the settling tanks, and is placed so that its lowest part is at a point one-half the height to which the solutions have to be raised. Thus if it be necessary to lift the solution an average of 25 ft. the lower part of the invert would require to be 12·5 ft. below this point in order to give satisfactory results. Two valves only are required, one in the bottom of the settling tank to let the solution into the siphon, and one—the air valve—to admit the air for the required pressure. The solution valve is of rubber on a long wooden or lead covered stem and is operated from the top of the tank. The air valve is located at a point close to the discharge of the siphon and above any possible contact with the solution. It will be seen, therefore, that there are no working parts to wear, and when the siphon is properly placed, there is no difficulty in starting it. For chlorine solutions, heavy lead pipe is used; a 4-in. pipe with a 1·5-in. air inlet using air at 15 lb. pressure has been found to lift 90 tons of solution a height of 18 ft. in three hours.

Precipitation.—Each precipitating tank is built of a capacity equal to that of a settling tank and is arranged with a sloping bottom for the easy removal of the precipitate; it also has perforated gas pipes to introduce the hydrogen sulphide gas which is used as a precipitant. This gas is now used alone, the use of sulphurous acid gas as an aid having been discontinued in most mills. In some mills the resultant solution from the hydrogen sulphide generator is used to assist the precipitation and to reduce the amount of hydrogen sulphide gas required.

Charcoal as a precipitant is used in a few mills. It is found to be very satisfactory, giving a much higher grade of gold than other precipitants, the fineness of a bar being seldom below 995. The apparatus necessary for charcoal precipitation and for the burning of the charcoal is much more elaborate than that required for other methods and requires close attention. All solutions are heated to a temperature of about 120°F. to drive off the excess of chlorine and to precipitate the lime, the whole is then filtered through sand filters before being sent to the charcoal vats or drums. The amount of solution carrying a certain metallic gold content only is allowed to flow through a vat. The capacity of the quantity of gold that a certain amount of charcoal will collect having been determined, the vats are then emptied into large shallow iron pans, built in a brick furnace and open to the air, where the whole is dried and reduced slowly to ash, which is then screened and fused to bullion.

Various filter presses are used for the collection of the gold sulphides from the precipitating tanks, those with the iron frame and distance frames being most general; the life of a set of iron plates under ordinary conditions is between 6,500 and 7,000 tons of ore treated. Wooden plates and frames have been used, the wood having been previously boiled in a pan of liquid paraffine until

thoroughly warmed and coated. The life of these plates has not been determined as yet, but from what is already known, it will be much greater than that of iron. They are much to be preferred to the iron plates for solutions carrying copper, and are much lighter and more easily handled. It is not, however, advisable to use them with pressures exceeding 40 lb. per sq. in., as owing to their construction they are liable to leak. However, it is seldom that pressures exceeding 25 lb. per sq. in. are required, and then only when air drying the sulphides.

Sulphide Roasting and Melting.—The sulphide roasting furnaces have not been materially changed from that described in THE MINERAL INDUSTRY, Vol. V., except that the muffles at some mills are made of fire clay, while at others they are of cast-iron sections to facilitate handling, the removable parts being those subjected to the most wear. A separate dust chamber is now attached to the muffle for the collection of any dust that may be carried off during the roasting operation, instead of allowing it to mix with the dust from the fire as formerly.

The mills treating Cripple Creek ores use oil-burning crucible furnaces for the reduction of the roasted gold slimes to bullion. In furnaces of this type, the oil residuum, similar to that used for the ore roasting, is thrown by a jet of steam or compressed air against a network of fire brick under the crucible, from an ordinary oil burner; the oil ignites and the rising flame circulates around the crucible; the time required to fuse a charge varies from 45 to 60 minutes when starting with a hot furnace.

Concentration.—A feature of the treatment of Cripple Creek gold ores, and one peculiar to this section only, is the use of tables or other concentrating devices for the saving of values after the soluble have been extracted. The gold in the ores is to some extent coarse and is also in the form of globular particles from the tellurides during the roasting; a condition which requires a lengthened time for the solution of the gold. Concentration, however, overcomes this difficulty as it removes the gold in this condition very easily and possesses the additional advantage of saving any unroasted iron sulphide or iron sulphide that has been sintered by too high a roasting heat. In operation, the tailings from the chlorinating tanks are discharged direct to a series of settling tanks, or to a separate tank and then elevated to settling tanks, or direct to feed launders of the concentrating tables. The pulp is sent first to a series of roughing tables, where a preliminary concentration takes place, and this concentrate, from four double-deck or six single-deck tables, is elevated to one finishing table for final concentration. The degree of concentration varies with the ore treated, but is seldom less than 50 tons of tailings to one of concentrates, and is often as high as 120 to 1. The saving made on the tables will average throughout 50% of the contained value. The concentrate thus made is shipped and sold to the smelter. The cost of concentration is comparatively light, as the pulp is already prepared for it, the only items of cost being labor, power, water and repairs. For labor, three men a shift can easily take care of 20 double-deck tables and accompanying machinery and handle 300 tons per day, or 150 tons per shift of 10 hours. The power required is safely estimated at 0·5 H.P. per table, and the supply of necessary water is from 500 to 700 gal. per ton of material concentrated.

Where water has to be pumped and economized, a system of settling tanks is arranged by which about one-third of the water used can be saved.

Metallurgical Work.—In all the modern plants, the laboratory forms a very prominent part and closest attention is given to all metallurgical operations. Complete analyses of all the ores to be treated are made, as well as partial analyses of every lot of ore purchased, and the best methods of mixing are determined with reference to the mechanical and chemical operations. Careful checks are made in the different departments to ascertain the losses of each operation and to bring them to a minimum, as well as to keep an accurate check on the bullion that should be produced. Chloride of lime (bleaching powder) and sulphuric acid are still used as the chlorine-producing chemicals for barrel chlorination, although in the vat process, liquid chlorine has found a foothold and much may be expected of it. At present, however, its price has been the chief factor against its greater use, and except in isolated places where transportation is high, it has been found cheaper to use the more bulky material. It is reasonable to suppose that, before long its cost will be very materially reduced, and means will be found by which the liquid chlorine can be shipped in more convenient and less expensive packages.

On Cripple Creek ores, the usual chlorine-generating, chemical charge for one ton of roasted ore is from 12 to 15 lb. of chloride of lime, averaging from 34 to 36% available chlorine, and 24 to 30 lb. of sulphuric acid 66°B. The excess of acid necessary over that theoretically required to liberate the chlorine from the chloride of lime is due to other soluble compounds in the ore, which consume a certain amount of acid before it completely satisfies the chloride of lime; furthermore an acid solution is required in order to get the best extraction. It is always necessary at the end of the chlorination to have an excess of gas. In some mills this is allowed to escape before starting the leaching; the best practice, however, is to leave it in the barrel where the wash water will take it up, thus getting the advantage of the solution in the chlorination.

The gold bearing solutions are assayed to determine their value; the method generally followed is to take from 1 to 10 assay tons of the solution, or its equivalent in cubic centimeters, pass hydrogen sulphide through it until everything it contains that will be precipitated by the gas has been thrown down, and then filter the whole through double or triple filter papers. The paper containing the precipitate is calcined in a fire clay crucible of 10 g. capacity and the ash mixed with a small amount of litharge and soda, enough to reduce a lead button of about 5 g., which is cupelled and the gold weighed in the usual way. By this method it is possible to make a very rapid determination of the value of a solution, the time required for the operation not exceeding one hour when the assay furnace is available.

It is difficult to get at the cost of treating ores at the different Cripple Creek mills, but from my experience the following figures, covering the average of several mills, give a close estimate:

	Per Ton.		Per Ton.
Labor, including office force salaries	$1·34	Removal and repairs	·45
Chemicals and supplies	·72	Miscellaneous expenses	·32
Fuel for roasting and power	·70		
		Total per ton	$3·53

Progress in the Cyanide Process during 1900.

By Louis Janin, Jr.

In the *Engineering and Mining Journal,* December 22, 1900, H. M. Crowther calls attention to the amount of gold rendered soluble in Mercur cyanide tailings exposed to the air for a brief period, by action of the cyanide still retained by the moisture in them in conjunction with caustic alkali. Lime will act fully as well as the caustic soda, if thoroughly mixed with the ore, and moreover being less soluble will not concentrate in the bottom of the pile owing to drainage. Where the configuration of the ground and other local conditions will permit it would seem advisable to conserve all tailings above $1 a ton for future treatment. For the recovery of gold from surplus solutions, Mr. William Orr, of Denver, has devised a method which has succeeded, so I am credibly informed, in recovering $1,098·95 worth of cyanide at a cost of $137·18.

Cyanide Treatment at Mercur, Utah.—D. C. Jackling* and W. M. Magenau† have contributed excellent articles on practice in this pioneer cyaniding district. The ores are locally classified as of three varieties: (1) Oxidized ores, almost entirely free from arsenic and mercury; (2) talcose ores formed by the decomposition of porphyry, and nearly free from base elements, but which disintegrate on contact with water and settle to an almost impervious mass; (3) base ores which are composed of a mixture of the preceding classes, with ore containing a large amount of sulphides. The clays accompanying these ores carry as high as 4% carbon, and at times contain organic compounds which rapidly decompose potassium cyanide. On oxidized ores exceedingly coarse crushing is employed. After screening the ore is mixed with quicklime and is taken to the leaching tanks. For filters, strips of wood are nailed on the bottom, covered with burlap and other strips nailed at right angles to the first to hold the burlap in position. Though channeling takes place, the effect is not apparent on extraction. But one strength of solution, applied in a series of percolations, is employed. The process usually occupies 60, but sometimes 120 hours. The extraction on oxidized ore carrying from $3 to $5 per ton is commonly 70 to 80%; on ore carrying above $5 it is normally above 80%.

In washing, the last cyanide solution is allowed to drain off, then a charge of water is run on, draining this off. An approved method of washing is to place a canvas filter over the charge and allow the wash water, run on in a full charge, to drain through this and then evenly through the ore. As a usual thing the amount of wash water is made to equal the amount of moisture retained by the tailings, so no waste solutions are made. Automatic zinc-cutting lathes are employed where zinc shavings are used. Solutions rarely contain over $3 to $4 per ton, while in several mills they contain from 60c. to $1. With weak solutions the average precipitation exceeds 90%, 3·5 cu. ft. of zinc being employed to each ton of ore treated daily—careful and even packing of the zinc is required as everywhere.

The clean-up as practiced by Magenau, is begun by shutting off the flow from

* *Mining and Scientific Press*, May 26, 1900.

† *Engineering and Mining Journal*, July 21, 1900; *Mining and Scientific Press*, April 21 and 28, and May 5, 1900.

a single line of boxes. The zinc in the two top compartments is transferred to iron kettles, without draining the solution from the boxes. The slimes at the bottom are removed by a scoop, the compartments refilled by zinc and the flow re-established. Only the top two compartments are treated, a concentration of the values having taken place here. No loss, it is stated, occurs through suspended gold passing off when the flow is re-established. The zinc in the iron tubs is then screened through a 4- to 16-mesh screen into a small tank. The supernatant solution, rich in suspended auriferous slimes, is decanted at once into a settling tank, where it remains until the succeeding clean-up, the excess of liquor after settling being charged back to a top compartment of the zinc boxes. The product of screening is dried on a circular cast-iron pan with a double bottom for steam circulation. The capacity of this dryer with steam at 40 lb. is 500 lb. (in ton charges) dried to 1% moisture in 6 hours. The dried product is sampled and sold. The following analyses show the variation in the composition of dried slimes:

	Au.	Ag.	Fe_2O_3 and Al_2O_3.	Ca.	Mg.	Zn as Metal.	Pb.	As.	Hg.	SiO_2.	Other Eleme'ts.
I.	4·56	0·05	3·00	3·20	0·07	38·28	1·20	0·25	0·10	6·10	7·58
II.	5·26	Trace.	0·92	2·78	0·48	55·38	0·33	0·71	0·31	2·12	14·85

W. M. Magenau* gives the cost at the Geyser-Marion mill as 67c. per ton, though during a month's run when 4,000 tons were treated the cost was only 50c.

The costs at the Mercur Gold Mining and Milling Co.'s plant are stated to be 68c. per ton, exclusive of royalty of 5c. per ton. In considering these costs it must be remembered that the crushing is exceedingly coarse and cheap, otherwise these costs of dry crushing and cyaniding would be unattainable.

At the De Lamar Golden Gate plant the ores are divided into three classes at the mine: (1) Oxidized, (2) talcose and (3) base, and are kept separate until after the roasting, when they are mixed together to go to the leaching tanks. The base ore is crushed to pass a 8-mesh No. 16 wire screen and is roasted in a Jackling mechanical furnace. The sulphur is reduced from 2 to 5% down to 0·75% and the arsenic from 1 to 2·5% down to 0·1%. The first solution containing 0·4 to 0·5% potassium cyanide is run on from below under a head of 14 ft. In eight hours it reaches the surface, when sufficient solution is run on the top to cover it to the depth of 2 in. It is then allowed to stand 16 hours. Then drawing off is commenced and lasts 48 hours, the solution being replaced constantly by fresh run on top. This solution is followed by a weaker (0·3 to 0·35%) solution for 48 to 72 hours, the time being determined by laboratory tests, and is then washed and drained for 24 hours. The total time between charges is from six to seven days. The strong solution running 0·45% comes off 0·33 to 0·35%. The rate of leaching is 0·75 to 1 in. per hour on oxidized ores and only 0·25 to 0·33 in. per hour on roasted ores, which have a tendency to cement in the tanks. Cyanide consumption is 0·9 lb. per ton, half of which is chemical and half mechanical. The solution before standardizing is rendered alkaline by 1 lb. of caustic soda to one ton of solution.

* *Engineering and Mining Journal*, July 21, 1900.

Cyaniding in the Black Hills.—The process has been extensively introduced here, but the plants have not been erected as a rule on the latest designs, any makeshifts being employed. The Homestake and allied companies, however, have awakened to the losses which have taken place during the last 20 years and built a substantial up-to-date plant that will doubtless give them a good profit.

J. M. Henton* describes the wet crushing with cyanide solution plant of the Dakota Mining and Milling Co. The modification adopted resembles crudely the treatment at the Crown mines of New Zealand, described by James Park.† The ore is crushed through a 6-mesh woven screen; 18% of the pulp remains on a 20-mesh screen, 12·6% on a 40-mesh, 7·4% on an 80-mesh, 7·4% on a 100-mesh and 49·4% passes through a 100-mesh screen. The pulp is run into an agitation tank, the battery is stopped, potassium cyanide is added and the solution is agitated for three hours, the slimes being run off by overflow. The sands remaining are also heated by percolation in a properly arranged vat.

Zinc dust is used for precipitation. When a clean-up is made the slimes are drawn off from the precipitating tanks and filter pressed. They are then dried in iron pans in a cast-iron muffle, crushed to pass a 0·25-in. screen and refined with sulphuric acid to which a small quantity of nitric acid has been added. At the Liberty Bell cyanide plant the tailings passing from the Wilfley tables, are exceedingly slimy and flow by gravity to the upper tier of tanks, being fed by distributors. The slimes are allowed to overflow through four overflow gates to the vat, and the tailings are discharged into the lower vats by means of four circular discharge doors. The tailings treated range in value from $1·40 to $2 per ton gold and 2 to 2·5 oz. silver. The itemized cost of treatment per ton during the three months of operation is as follows:

	May.	June.	July.		May.	June.	July.
Labor	$0·318	$0·235	$0·255	Taxes, insurance and depreciation	$0·212	$0·101	$0·135
Chemicals (*a*)	0·973	0·390	0·371	Miscellaneous	9·018		0 002
Assaying	0·044	0·030	0·043				
Electric lights		0·004	0·006				
Shipping bullion	0·009	0·001	0·001	Totals	$1·574	$0·761	$0·813

(*a*) Includes cyanide, lime, sulphuric acid and zinc.

In Montana, particularly in Fergus County, a number of cyanide plants have been built to treat the auriferous limestones and porphyries of the Judith and Moccasin Mountains. The ore, like that of Mercur, requires a coarse crushing only, but the increasing percentage of sulphur will render necessary expensive modification of the plant when the oxidized ore is exhausted. The ore is crushed to 0·25 in. mesh and conveyed to leaching tanks 3 ft. deep. Solution containing 0·4% KCy is run on from the bottom and allowed to remain 8 hours. This is drawn off and a leaching solution of 0·2% cyanide is allowed to run on the top for 48 hours. After drawing off this is followed by a first wash carrying 0·1% cyanide, which remains on 2 hours and which is followed by a wash of clear water. Zinc shavings, in ordinary zinc boxes, are used for precipitation. After treatment with sulphuric acid the slimes are washed with five waters, then roasted at a dull red heat, and fluxed with sodium bicarbonate and borax glass, yielding a bullion of 920 fine.

* *Mining and Scientific Press*, March 10, 1900, p. 261.

† *Transactions of the American Institute of Mining Engineers*, Vol. XXX.

The Treatment of Telluride and Sulphide Ores.—This problem, a comparatively easy one in Colorado, has been a bugbear in west Australia and in London. Two distinct methods are interestingly described by Mr. Alfred James,* the condensed extract from his paper, being as follows: The difficulty in the treatment has been due to the considerable percentage of tellurium minerals, of lime, alumina and magnesia salts in addition to the usual constituents of gold-bearing reef matter. A typical analysis of Kalgoorlie sulphide ore may be stated as: SiO_2, 50%; Fe, 10%; Al_2O_3, 5 to 20%; MgO, 2 to 5%; S, 3 to 7%; Cu, 0·1 to 0·3%; Zn, 0·02%; Sb, 0·02%; Te, 0·3 to 0·1%; $CaCO_3$, 6 to 17%, and Pb and As, trace. About 2% of soluble salts as sodium chloride and magnesium sulphate is also present. The iron pyrites varies from 3 to 7%. The amount of calcite precludes chlorination, except after concentration, a treatment which is unsatisfactory as the ore is liable to form slimes. It is noteworthy to record as a result of many experiments that roasting can be accomplished in spite of the very volatile nature of the tellurium minerals without loss of gold beyond that carried off mechanically in the dust. Ordinary cyanide bottle tests on raw ore showed an extraction of from 60 to 77% for 16·5 hours' agitation. The residues from the 60% extraction when roasted and re-treated by cyanide yielded an additional extraction of 33%, making a total extraction of 93%. In cyanide tests it was shown that fine grinding to at least 90-mesh was absolutely essential to successful work. On roasted ore an extraction of 87% was obtained by a 16·5-hour treatment with cyanide. These results showed that the agitation of finely ground raw ore with cyanide should be effected for ores containing even a large quantity of sulphide, but not exceeding 0·03% Te and of a value per ton of 1 oz. gold or less. In this case high percentage extractions is subordinate to low treatment cost. With lower grade ore, percolation and re-treatment are satisfactory provided that the consumption of cyanide by copper and iron is kept at a low point; for instance by the use of dilute solutions. Ores richer than 1 oz. gold could be treated by roasting, followed by amalgamation or not, depending upon the nature of the gold in the roasted material. At present there are two methods of treatment known as the "Marriner," and the "Diehl" processes. After many difficulties the Marriner process was developed to an extraction efficiency of 93 to 94% at the Great Boulder Main Reef, at the South Kalgurlie mine and at Ivanhoe, and it has been adopted by many plants at Kalgoorlie. The special points of the operation are excessively fine grinding by pans which simultaneously amalgamates the coarse gold and an auxiliary concentration and settling should the ore be rich. Agitators and filter presses have been introduced to obviate the difficulty that arose in the treatment of this finely ground material by percolation and filtration. The treatment cost is officially stated at 20s. per ton, of which 4s. is for roasting and 6s. to 8s. for filter pressing. The residues assay from 1 to 2 dwt. depending upon the value of the original ore. The pioneer plant, the Great Boulder Main Reef, consists of ball mills, vertical multiple hearth furnace, tailings wheel, 5-ft. pans, agitators, two sets of filter presses, and precipitation boxes. The latest plant of this type, now being erected by the Great Boulder Proprietary Co., consists of 1 No. 8 Gates breaker;

* Paper read before the Institution of Mining and Metallurgy, June 20, 1900.

4 Gates fine crushers; 10 Griffin mills; 12 Edwards roasting furnaces; 12 grinding pans; 6 settlers; 1 three-throw pump; filter presses for eliminating moisture; cone mixer or breaker; 1 three-throw pump; central agitation vat, 14 ft. diameter by 16 ft. deep, with radial arms; 12 other agitation vats, of sizes varying from 15 to 20 ft. diameter by 5 ft. deep; montejus; filter presses and extractor boxes.

The concentration-sluicing-bromocyanide process, also called the Diehl process, involves the use of Sulman's bromocyanide, plus fine grinding, agitation, filter pressing and concentration. It avoids the roasting necessary in the Marriner process, crushes wet, amalgamates, concentrates and separates the sands and slimes, regrinding the former in tube mills followed by agitation and filter pressing. The process is still under development and details of regular results with costs are not yet available. The first run of 250 tons, however, is reported to have yielded a 90% extraction. Mr. James states that while the Diehl process saves from 2s. 6d. to 4s. per ton over the Marriner process by the avoidance of roasting, it involves a royalty charge as well as an additional cost for bromocyanide, the latter in amount which may readily equal the cost of roasting. Furthermore, the Diehl process calls for finer grinding, a heavier consumption of cyanide than with roasted ores, due to the reaction of bromocyanide and of the sulphides, copper, and metallic iron contained in the pulverized ore, smelting charges, or the probable loss of gold from roasting the concentrates charged with the salts found in Kalgoorlie water; and finally higher residues than in the Marriner process. According to Mr. James,* the costs of the Marriner process are as follows: Rock bearing, $0·06; ball mill, $0·369; furnace, $2·068; grinding, $0·323; filter press, $1·07; cyanide, $1·45; steam, $0·66; smelting, $0·072; assays, $0·046; water and condenser, $0·202; management, $0·25; total, $6·56.

Filter Press Treatment of Slime in Western Australia.—Mr. John K. Wilson discusses this subject in a separate monograph, which is given on pages 779-792 of the present volume.

Recovery of Gold from Waste Solutions.—In the Transvaal, according to W. A. Caldecott, when the final tailings of original charges on the Rand contain 18 grains, some 3 grains can be extracted by simple water washing. In general on the Rand the difficulty of cyanide treatment is not in the solution of the gold, but in the elimination of the dissolved metal from the charge. Mr. Caldecott has devised a simple method of recovering gold from solutions commonly run to waste, which is described in the following rather free translation from an article read by him before the International Congress of Mining at Paris: This method consists in principle in neutralizing the free alkali of solution, adding a small quantity of a metallic salt, filtering, then acidulating slowly and precipitating the gold by zinc scraps. The result of the simple acidulation of a cyanide solution, hot or cold, is to precipitate the greater portion of the gold in the form of aurocyanide. The gold of a cyanide solution, however rich, is precipitated completely by the action of filiform zinc and agitation. Any acid may be employed in acidulation, but the most economical is commercial sulphuric acid or sodium bisulphate, containing 29% free acid, and a by-product in the manufacture of

* Private communication.

sodium sulphate. In place of zinc sulphate, the soluble salts of the heavy metals which form insoluble combinations with cyanogen; such as those of iron, lead or copper; but the salts of zinc ore preferable. The principal chemical reactions arising from the addition of acid and of zinc sulphate to the solution, may be represented partly by the following equations:

$$2AuKCy_2+Ca(OH)_2+H_2SO_4=2AuHCy_2+CaSO_4+K_2SO_4+2H_2O \text{ and}$$
$$2KCy+K_2ZnCy_4+K_4FeCy_6+4ZnSO_4=3ZnCy_2+ZnFeCy_6+4K_2SO_4.$$

The precipitate generally contains enough gold to make it a valuable by-product and contains the greater part of the cyanogen of the original solution.

To employ the foregoing principles iron pipes and wooden tanks with filter cloths above wooden gratings can be used. The solutions to be treated are brought together in a sump at the lowest part of the plant, and afterward are pumped up to a large tank in which the neutralization by acid and the zinc sulphate treatment takes place. The zinc scraps are placed in a small tank adjoining the neutralizing tank but at a higher level, and the sulphuric acid or acid sulphate added from time to time. A small stream of water or residual solution is allowed to run into this tank and is drawn off, carrying with it the sulphuric acid and the zinc sulphate in solution. This is discharged into the stream of solution to be treated, as it enters the acidulation tank. Three to four pounds of acid sulphate per ton of solution treated suffices as a general thing. The zinc sheets are suspended from iron wires or are allowed to rest on a screen near the bottom of the tank. The quantity of scrap zinc usually required is from 0·5 to 1 lb., with five times its weight of acid sulphate to each ton of solution treated. It requires about 0·5 lb. of sodium bisulphate per ton for each 0·001% of alkali in solution.

The presence or absence of soluble cyanogen compounds may be determined by addition of (1) an excess of a caustic soda solution, (2) a strong solution of ferrous sulphate slightly oxidized, or (3) an excess of hydrochloric acid, when a blue or green precipitate is formed on agitating the liquor.

After neutralization of the free alkali and the precipitation of the cyanogen compounds the solution is drawn off into the large filtering tank, where it is classified and then run continuously to the tanks or boxes for precipitation by zinc shavings or by the zinc-lead couple.

For a 100-stamp mill a complete plant for treating waste solutions consists of: (1) One sulphate tank, 6×6 ft., in which the zinc clippings are dissolved. (2) One storage tank, 14 ft. in diameter and 6 ft. deep. The waste solution and the sulphate solution are run into a box elevated above this tank, so that they may be mixed and when mixed run through an opening on top of the box to the tank below. (3) One filtering tank 20 ft. in diameter and 6 ft. in depth. In this the classification of the liquor is finished. (4) Six precipitation tanks, for zinc shavings, 5 ft. in diameter and 3 ft. deep.

The storage tank is placed a little lower than the sulphate tank, while the precipitation tanks may be on the same floor as the precipitation boxes if low enough to permit the complete discharge of the filtering tank. The cost of treating residual solutions has been proven in actual work to be less than 12c.

per ton of solution treated. It follows therefore that any solution containing over 3 grains of gold per ton will return a profit for treatment. Zinc shavings form the principal expense; 0·5 lb. of these can be estimated per ton of solution.

Beyond the indirect advantage due to the destruction of the cyanide, the gold obtained, less the cost of precipitation represents a net profit. Briefly this process has increased the gold from 3 to 6 grains per ton of ore crushed where the solutions treated varied from 20 to 50% in weight of the ores crushed. In 1899 an experimental plant was run for a month at the Rose Deep mine. The solutions treated contained from 4 to 43 grains per ton and the quantity varied from 12 to 34 tons per day. During the experiment, except for two days when channels formed in the zinc, a complete precipitation and a complete destruction of cyanide was obtained. The clean-up gave a bar of 30 ounces.

Recovery of Gold from Tailings After Cyaniding.—H. M. Crowther* calls the attention of metallurgists to the heretofore unrecorded fact that the amount of soluble gold in cyanide tailings increases greatly within a comparatively short time after discharging (three months to one year) especially in the presence of caustic alkali. He advances the theory that it is not the contained cyanide that brings about these changes, but the liberated hydrocyanic acid, aided by air and sunshine, and protected by the caustic alkali, the presence of which is essential. Tests made by Mr. Crowther on the tailings dumps at Mercur, composed of tailings which contained when they left the mill about 0·4 lb. cyanide, 0·6 lb. caustic soda, 20% moisture and 8c. dissolved gold per ton showed moisture 13.2%, gold $1·05, and soluble gold 56c. The extraction was obtained by percolating a half ton of water through each ton of tailings. Mr. Crowther recommends that the tailings be so prepared by the use of a final wash water containing caustic soda as to leave several pounds per ton in the tailings. In treatment on a large scale tailings which yield 50c. per ton can profitably be worked.

The Electrical Precipitation of Gold.—The result of experiments by Dr. T. K. Rose,† with amalgamated copper plates and with mercury as cathodes in the electrolytic precipitation of gold from cyanide solution, shows that satisfactory results can only be obtained when a current of low density is employed. With 0·01 ampere or less per sq. ft. of cathode surface, the gold is precipitated and simultaneously amalgamated, the plates keeping a good condition during the 24 hours of use while collecting 0·5 oz. of gold per sq. yd. of plate. With currents of greater density part of the gold is deposited as a non-adherent black powder which is easily rubbed off but not easily detachable by a water jet, nor is this powder easily amalgamated. As the current density is increased, the percentage of non-amalgamable gold is increased until at 0·30 ampere per sq. ft. of cathode surface about one-half of the precipitated gold is non-amalgamable. In other experiments it was shown that the decomposition of cyanide is greater when amalgamated plates were used in place of lead or iron plates. It was also apparent that more gold is deposited on copper than on lead, especially when rich solutions were treated. From these results it is doubtful that either mercury or amalgamated copper plates will ever be satisfactorily used as cathodes for the electrolytic precipitation of gold from cyanide solutions.

* *Engineering and Mining Journal*, Dec. 22, 1900.

† Paper read before the Institution of Mining and Metallurgy, London, April 25, 1900.

GRAPHITE.

THE production of crystalline graphite in 1900 was 4,103,052 lb., valued at $164,122 as against 3,632,608 lb. ($145,304) in 1899, while of amorphous graphite there were produced 1,045 short tons ($8,640) and 1,030 tons ($8,240) in the respective years. As in the past few years, the crystalline graphite was mined at Ticonderoga, N. Y., and in Chester and Berks counties, Pa., while the amorphous graphite was derived principally from Rhode Island, Alabama and New Mexico. The so-called "Baraga" graphite from Baraga County, Mich., which is used for paint, is classed and reported as slate pigment.

THE PRODUCTION, IMPORTS AND CONSUMPTION OF GRAPHITE IN THE UNITED STATES.

Year.	Production. (a)		Imports.		Consumption.	
	Pounds.	Value. (b)	Pounds.	Value.	Pounds.	Value.
1896.....	405,006	$18,225	33,824,000	$437,189	34,229,006	$455,414
1897.....	993,138	44,691	19,113,920	270,952	20,107,058	315,643
1898.....	1,647,679	82,385	30,199,680	743,820	31,847,359	826,205
1899.....	3,632,608	145,304	41,586,000	1,990,649	45,218,608	2,135,953
1900.....	4,103,052	164,122	32,298,560	1,390,141	36,401,612	1,554,263

(a) Production of refined graphite only; of amorphous graphite there were produced 574 short tons ($3,850) in 1896, 1,200 tons ($11,400) in 1897, 1,200 tons ($11,400) in 1898, 1,030 tons ($8,240) in 1899, and 1,045 tons ($8,640) in 1900. (b) Nominal.

Alabama.—The Alabama Graphite Co. continued operations in its mines in Cleburne County. The material was shipped largely to Cincinnati and was used for foundry facings.

Michigan.—The Hathaway Graphite Manufacturing Co. owns a mine at L'Anse, Baraga County which, it is stated, yields a good quality of amorphous graphite suitable for foundry facings, crucibles and electric carbons.

New Mexico.—The Standard Graphite Co. of Scranton, Pa., made a few small shipments from Raton for experimental purposes. The product is amorphous graphite.

New York.—There was an increased production from the mine near Hague. A discovery of a new deposit near Ticonderoga was reported, but no active steps have been taken toward its development.

Pennsylvania.—(By W. F. Downs.)—There was much interest manifested in

the industry during 1900, and a number of new discoveries was reported. The existence of graphite throughout a large portion of the ridge extending from Phœnixville to the Brandywine River seems very probable. Occasionally, pockets are found yielding nuggets and masses of nearly pure graphite such as form the basis of the producing mines in this region, but more often the mineral is associated with iron oxides, quartz and feldspar. The latter variety of ore is dressed and refined with more difficulty, but when the plants are remodeled so as to handle it properly the industry will be on a firmer basis. As yet no workings have gone below 150 ft. and little is known as to the permanency of the deposits in depth. The companies in operation in 1900 were the Philadelphia Graphite Co. and the Federal Graphite Co. at Chester Springs, the Pennsylvania Graphite Co. near Mertztown and the Boyertown Graphite Co. at Boyertown. A low-grade product used for foundry facings was mined at Byers on the Pickering branch of the Philadelphia & Reading Railway.

Rhode Island.—The mine of the Rhode Island Graphite Co. was closed down during part of the year. A fine grade of graphite was obtained from the second level, and a large block excavated weighing nearly 27 tons.

South Dakota.—A discovery of graphite was made on the property of the Copper Cliff Mining Co. west of Rochford. The company secured the patent rights of a German process for refining graphite and intends to install a refining plant in Chicago.

WORLD'S PRODUCTION OF GRAPHITE. (IN METRIC TONS.)

Year.	Austria	Canada	Ceylon. (*d*)	Germany.	India.	Italy.	Japan.	Russia.	Spain.	Sweden	United States. (*b*)	Totals. (*e*)
1894.....	24,121	63	10,718	3,133	1,623	1,575	1,091	(*a*)	10	107	350	42,683
1895.....	28,443	199	13,711	3,751	(*a*)	2,657	77	(*a*)	*Nil.*	7	171	49,050
1896.....	35,972	126	10,463	5,248	(*a*)	3,148	215	(*a*)	*Nil.*	14	184	55,356
1897.....	38,504	396	19,275	3,861	61	5,650	204	(*a*)	(*a*)	99	450	69,311
1898.....	33,062	1,107	78,509	4,593	22	6,435	346	98	10	50	824	125,006
1899.....	31,819	1,105	32,067	5,196	1,548	9,990	55	(*c*)	(*a*)	500	1,648	83,928

(*a*) Not reported in the government statistics. (*b*) Crystalline graphite. (*c*) Statistics not yet published. (*d*) The figures for 1897 and 1899 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports for that year, which amounted to 24,349 metric tons. (*e*) The United Kingdom produced 41 tons in 1895, which is included in the total for that year.

Brazil.—Graphite is known to occur near Miguel de Arassuahy in the State of Minas Geraes, but no attempt has been made to exploit the deposits. Discoveries of graphite have also been reported from time to time in other sections of the country.

Canada.—The output in 1900 was 1,922 short tons, valued at $30,940. Extensive development work has been done on the property of the Ontario Graphite Co., Ltd., in the County of Renfrew, Ont. The product is a mixture of amorphous and foliated graphite, assaying about 84%C. It is used for foundry facings and paint.

Ceylon.—The mines of Ceylon, which furnish large quantities of the finest crystalline graphite, are located chiefly in the western and central districts. It is found in veins of irregular occurrence and extent, which break through crystalline rocks of granulite character. The vein filling comprises feldspar, rutile, pyrite, biotite and calcite, besides graphite. Dr. E. Weinschenk attributes the

formation of the deposits to vapors carrying carbonic oxide and cyanogen compounds which ascended from great depths.

Germany.—The entire output amounting to about 5,000 metric tons annually, comes from Passau in the eastern part of Bavaria on the Austrian frontier. The deposits are lenticular in shape and occur along the contact of granite and gneiss. They are worked by the individual land owners in a crude way which causes great waste; it is stated that only 10% of the material is recovered. The graphite is used mostly in the manufacture of crucibles for which purpose clay is added after cleaning the product. The crucibles are good conductors of heat and show great resistance to sudden changes in temperature and to the corrosive action of molten metals. For a full description of the occurrence, origin and chemical composition of Bavarian graphite, the reader is referred to THE MINERAL INDUSTRY, Vols. II. and VII.

Italy.—The Italian graphite mines are located in the Pinerolo district of Piedmont, and extend from Cumiana on the north along the Cotian Alps to the heights which dominate the Pellice River. The output in 1899 was 9,990 metric tons, valued at $55,944. The following description of the occurrence and methods of mining, is taken from an article by V. Novarese.* In width the graphite belt varies considerably being 1,000 to 1,300 ft. wide near Giavone, and reaching its maximum breadth in the valley of the Chisone and Germanasca, where it is no less than 2·5 miles wide. At the lower end of the Val Pellice the breadth is much less and gradually diminishes as one proceeds southward. The deposits occur in a garnetiferous mica schist, and range from a few inches to 10 ft. in thickness. The mineral has all the properties characteristic of graphite—black color, semi-metallic luster, soft and more or less unctuous according to the greater or less purity, the purest being the least lustrous. On combustion it leaves a siliceous ash with mere traces of iron. The schistose material is so intimately mixed with the graphite that it is practically impossible to enrich the poorer grades by mechanical sorting or separation. A number of assays made in the laboratory of the Italian Geological Survey showed from 10 to 85% carbon, while the specific gravity ranged from 2·25 to 2·38. The raw product is shipped direct from the mines to the mill, where it is ground and packed. The final product contains about 61% pure mineral and has a value of 15s. to 19s. per ton at the mines and about 38s. packed and loaded on cars at Pinerolo.

ASSAY OF GRAPHITE BY BLAST AND BY FUSION.

BY F. S. HYDE.

EXCLUSIVE of the more elaborate methods by combustion and subsequent weighing as carbon dioxide, the choice lies between direct oxidation by blast (or muffle) and the method by fusion with caustic potash. In the one, the determination is made by loss through oxidation; in the other, the graphite is obtained and weighed in the purified state. Both of these methods have advantages in their simplicity; but for manufacturing purposes, the blast is superior for ascertaining the internal structure, refractory properties and suitability of certain graphites for metallurgical operations.

* *Bolletino del R. Comitato geologico d'Italia*, 1898, Vol. XXIX., pp. 4-36.

In the fusion method, the mineral matter is removed by the action of the molten alkali, while the graphite remains purified and undissolved, irrespective of its refractory properties. The sample should be finely pulverized, unless the original consists of a powder, or thinly laminated particles, which can be easily penetrated by the molten caustic. Many samples, however, resist reduction to powder, beyond a certain point, and the use of a blast, with free access of air, becomes almost imperative for an accurate determination. The same holds true with certain samples to be tested in the form and size as milled by the manufacturer.

On account of the tendency to low results by fusion, the following assays on two milled products are submitted for comparison.

Method.	Fine Product A. Each Assay, 1 Gram.		Flaky Product B. Each Assay, 0·5 Gram.	
	Moisture and Volatile Matter.	Graphite	Moisture and Volatile Matter.	Graphite.
	%	%	%	%
Direct Blast	2·05	49·55	0·90	87·3
	2·19	49·60	0·86	87·0
	2·32	49·30	1·03	87·07
	S. & S. Filter.	%	S. & S. Filter.	%
Fusion with caustic potash in silver crucible.	11 cm. No. 589, direct	42·90	11 cm. No. 589, direct	79·90
	11 cm. No. 589, washed	44·27	11 cm. No. 589, washed	84·10
	11 cm. No. 589, washed	45·85	11 cm. No. 589, washed	85·84
	11 cm. No. 589, washed	44·30	11 cm. No. 589, washed	87·30
	7 cm. No. 590, washed	47·10	7 cm. No. 590, washed	87·00
	11 cm. No. 590, washed	47·95	11 cm. No. 590, washed	87·40

Method by Blast.—Allowance should be made for free and combined moisture and sulphurous and organic volatile matter. From 0·5 to 1·0 g. of the pulverized substance is weighed in a platinum crucible, which is then placed in a vertical position, covered and subjected to a red heat for one minute over a Bunsen flame. On cooling to a low red heat, the crucible is momentarily uncovered and rotated to oxidize any traces of sulphur, which, when present, usually pass off with slight fumes and odor of sulphur dioxide. Should sulphur be present in larger amounts, proceed cautiously, reheating and cooling, until no more fumes or odor are noticeable. Mere heating under cover is not sufficient to drive out sulphur from pyrites—oxidation at a low red heat seems essential. Tests have shown that such procedure gives concordant results without appreciable oxidation of graphite. Having estimated all matter volatile at a low red heat, the crucible and cover are inclined and subjected to a direct, continuous blast maintained by compressed air. The lamp should be regulated to give a clean blue flame without unnecessary noise, and the graphite should be stirred occasionally with a stout platinum wire to facilitate oxidation. The operation may require from one to five hours according to the nature of the graphite; but usually, not more than two and one-half hours.

Method by Fusion.—Use a large silver crucible of about 120 g. weight. From 35 to 40 g. C. P. caustic potash (free from carbonate) are melted in the crucible over a very low Bunsen flame and fusion maintained at a temperature below an incipient red heat—just enough heat to produce a clear liquid melt. From 0·5 to 1·0 g. of the powdered graphite is carefully introduced on top of the melt (the flame being temporarily removed); the crucible is then covered, the flame

replaced and the contents allowed to simmer quietly, with occasional rotation, for half an hour. Increasing the temperature does not improve matters and may cause loss. The melt, after cooling, is dissolved in about 250 c.c. hot distilled water, and filtered by suction on a weighed filter (preferably Schleicher and Schüll's No. 590—11 cm.) which has previously been treated with 1:10 caustic potash, and then with 1:4 hot dilute hydrochloric acid. This washing with alkali and acid is essential and is preparatory to the subsequent filtration with the same chemicals. For example, one filter taken directly from the package weighed 0·8123 g., and after treatment, 0·7913 g., a loss of 0·0210 g., equivalent to 4% on 0·5 g. graphite taken for assay. After collecting and washing the graphite on the filter, the iron oxide is dissolved with hot 1:4 hydrochloric acid, and may be determined separately in the acid solution. The filter, containing the purified graphite is thoroughly washed with hot water, and dried in the air bath at 70°C.

The results with the blast are remarkably concordant, due, no doubt, in a large measure to the fact that the operation is performed in a single piece of apparatus; whereas, in the fusion method, there is the liability of loss through lightness and oxidation of particles, from overflow from the subsequent treatment in casserole and on suction filter, and even from the charring of weighed filter if dried above 70°C. Filter paper which has been washed alternately with acid and alkaline solutions of moderate strength becomes exceptionally tender and will hardly withstand prolonged heating beyond 70°C. Asbestos fiber would require similar treatment before use, and even a Gooch filter is not so convenient or simple as good paper supported with a washed linen cone, for obtaining graphite by direct weight. Furthermore, it is not always possible to judge when the action of the molten alkali is complete. For instance, with the flake product "B," the purified graphite obtained by fusion showed only 98·26% graphite before the blast, and the presence of ash was very evident to the eye, indicating that the molten alkali had not entirely penetrated the original substance. Another sample (part of "A" consisting of fine powder) gave after treatment by fusion a product 99·12% pure by blast, the ash being visible. These facts, however, hardly account for the lower results by fusion, which may be due to mechanical losses and possibly to partial oxidation. One of the lowest results was obtained when the sample was weighed in the silver crucible first, and the caustic potash allowed to melt down on top. That the power of penetration of molten caustic is somewhat dependent on its nature and temperature of fusion seems to be indicated by the following experiments in which C. P. caustic soda was substituted for caustic potash. Thus the flaky product "B" assaying 87% graphite by caustic potash fusion, gave 84·92% with caustic soda. Repeating this experiment on the same material gave 84·26% with caustic soda. As with the caustic potash fusions, the temperature was just sufficient to maintain a liquid melt, and extra precautions were taken to avoid mechanical loss. The product thus obtained by caustic soda was 99·64% pure by blast, the ash being slightly visible.

A separate lot of similar material assaying 87·54% by blast was then subjected to fusion with caustic soda at an incipient red heat, with the result that only 75·60% graphite was obtained, the loss being evidently due to oxidation in con-

tact with red hot alkali. The purified product yielded 99·74% by blast, the ash being slightly visible. The inference is that caustic potash gives higher results than caustic soda, but the latter yields a product of greater purity.

Notwithstanding the tendency to low results, the fusion method is one of neatness, and may be employed when the sample contains material fusible at the temperature of the blast, or when facilities for a continuous blast are lacking. Besides, it obviates preliminary determinations for moisture or other volatile matter. Alumina, lime, and magnesia may be determined in the alkaline filtrate and iron in the acid washings from the graphite residue. For sulphur, a separate determination is preferable, either by treating with aqua regia or by a fusion with oxidizing agent.

It may be well to note that silver crucibles after caustic alkali fusion are more easily cleaned than platinum crucibles which have been coated with fused particles of iron and mineral matter. On the other hand, silver is susceptible to sulphur, and graphite is not always free from this element.

In commercial transactions, it would be preferable to specify either the blast or the fusion method for general simplicity, convenience and comparisons.

GYPSUM.

DESPITE the extraordinary increase in the output of gypsum in 1899, the production continued to advance, reaching in 1900 a total of 484,202 short tons. Michigan, Kansas and Iowa are the leading States in this industry, their combined output amounting to over 75% of the total. The Kansas deposits, according to Grimsley,* form a belt trending N.E. and S.W. across the State with a width of from 5 to 140 miles. The center of the manufacture of plaster is in Dickinson and Saline counties. Reference may be made to his report for details as to the occurrence, character and economic importance of the Kansas deposits.

PRODUCTION OF GYPSUM IN THE UNITED STATES. (*a*) (IN TONS OF 2,000 LB.)

States.	1898.	1899.	1900.	States.	1898.	1899.	1900.
California	3,875	3,663	*e* 3,500	Oregon	150	500	450
Colorado	1,570	1,600	4,000	South Dakota	3,750	600	750
Ind. Ter. and Oklahoma.	15,229	20,750	16,975	Texas	24,417	34,214	42,000
Iowa	38,338	51,958	92,201	Utah	*e* 3,000	1,700	2,247
Kansas	49,720	82,016	*e* 90,000	Virginia	8,125	12,773	10,885
Michigan	93,181	144,776	150,000	Wyoming	3,633	2,817	2,995
Montana	400	304	325				
New York	46,477	39,390	42,874	Total	314,865	422,061	484,202
Ohio	*e* 23,000	25,000	25,000				

(*a*) Statistics reporting the amount quarried. (*e*) Estimated.

GYPSUM IMPORTED INTO THE UNITED STATES. (IN METRIC TONS.)

Year.	Ground or Calcined.			Unground.			Value of Manufactured Plaster of Paris.	Total.
	Quantity.	Value.	Per Metric Ton.	Quantity.	Value.	Per Metric Ton.		
1896	3,348	$22,058	$6·58	183,165	$193,549	$1·06	$11,722	227,329
1897	2,707	17,028	6·29	165,812	178,686	1·08	16,715	212,429
1898	3,021	18,500	6·12	168,723	181,364	1·09	40,979	240,843
1899	3,317	19,250	5·80	199,724	220,603	1·10	58,073	297,926
1900	3,159	19,179	6·07	213,239	229,878	1·08	66,473	315,530

PRODUCTION OF GYPSUM IN THE PRINCIPAL COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Algeria. (*b*)	Canada.	France. (*b*)	Germany. (*c*)		Greece.	India.	United Kingdom	United States.
				Baden.	Bavaria.				
1894	23,900	202,877		40,652	25,267	85	3,220	155,905	273,553
1895	45,474	205,187	2,456,150	29,895	21,773	113	6,816	180,738	237,399
1896	37,512	187,818	2,051,124	32,801	28,799	120	7,605	196,404	201,305
1897	36,750	217,392	2,004,339	40,702	26,153	51	8,187	184,287	272,493
1898	37,337	198,908	2,115,261	28,037	25,688	83	8,390	199,174	285,644
1899	39,950	221,862	1,978,963	29,419	29,727	81	6,546	215,974	382,891

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) A part of the product is reported as plaster of Paris. In converting this to crude gypsum it has been assumed that the loss by calcination is 20%. (*c*) Prussia is a large producer of gypsum, but there are no complete statistics available.

* Special report on Gypsum and Gypsum Cement Plasters. *The University Geological Survey of Kansas*, Vol. V., 1899.

IRON AND STEEL.

BUSINESS prosperity in all branches of the iron and steel industry and increased exports of crude and finished iron and steel products helped to consume the enormous output of pig iron during 1900, which was the greatest yearly production yet recorded. The year 1900 has been conspicuous in the number of new plants erected, a result due mainly to the large consolidations that were made in the iron trade during the past three years. The Carnegie Steel Co. completed new plate mills at Homestead and a new basic open-hearth plant at Duquesne containing 12 fifty-ton furnaces, and had under construction two new blast furnaces at the Carrie works, a bridge across the Monongahela River to convey the hot metal to the steel plant at Homestead and a large merchant bar mill at Duquesne. With the new Carrie furnaces the Carnegie Steel Co. will be able to make 3,000,000 tons of pig iron annually and with the completion of the new open-hearth furnaces at Duquesne its annual capacity for Bessemer and open-hearth steels will approximate 3,300,000 tons. Its plate capacity is 2,500 tons daily and during 1900 the record of the Edgar Thompson mill at Bessemer averaged over 2,200 tons of rails for every working day. The Jones & Laughlins, Ltd., is building four modern blast furnaces, each of 600 tons daily capacity. Two of these were completed and in blast during 1900. The American Steel & Wire Co. has nearly completed the 600-ton blast furnace on Neville Island. The Pressed Steel Car Co. has increased its daily capacity to 60 or 70 completed cars. The Union Steel Co. is erecting a large plant at Donora, 40 miles from Pittsburg, which is to consist of modern blast furnaces, open-hearth steel plant and rod, wire and nail mills. Additional details of blast furnace construction are given later in this article. Among other new iron and steel plants are the Pennsylvania Malleable Iron Co. at McKees Rocks, the steel casting plant of the Pittsburg Steel Foundry at Glassport, the Sharon Steel Co. and the Sharon Steel Hoop Co. at South Sharon.

The foreign trade which fell off considerably in 1899 due to the extraordinary demand for domestic consumption, was developed to a great extent during 1900. The Carnegie Steel Co. maintained branch offices in Mexico, Russia, England and Canada, and other companies were represented abroad. A move toward the development of foreign trade was made by the Carnegie Steel Co., which shipped some of its product via the Pittsburg, Bessemer & Lake Erie Railroad to Conneaut, thence to Ontario via the Welland canal and finally to Liverpool. High freight rates have handicapped the development of foreign trade, but a betterment of conditions is looked for either by a Government subsidy or by a consolidation of shipping interests with the large producers. The development of the export trade has been due to the liberal use of mechanical devices for the saving of labor, which has reduced to a minimum the cost of handling both the

raw materials and products. At the iron and coal mines the use of electric and compressed-air drills, improved explosives, and scientific methods of mining, hauling and elevating the material has materially reduced the mining costs, while mechanical appliances at coke ovens has lessened the cost either by diminishing the labor cost or by affording a larger yield; furthermore the collection of by-products at some plants has cheapened the cost of the fuel obtained. In the transportation of iron ores from Lake Superior to the Lake ports, vast sums have been expended for docks and larger vessels and barges, which has lessened the cost in this part of the industry. On the railroads, the rolling stock has been improved by the construction of larger cars and more powerful locomotives so that rich ores can be transported fully 1,500 miles at so low a cost as to replace the leaner local ores. While the wages paid for American labor are generally higher than in other countries, the output per man has been increased so considerably by the liberal use of labor-saving devices that the labor cost per unit of product is often less in the iron and steel industry of the United States than elsewhere.

During 1900 important consolidations were made, notably the Carnegie Steel Co., the American Bridge Co., American Sheet Steel Co., Crucible Steel Co. of America. The largest of these was the Carnegie company, with a total capitalization of $320,000,000, one-half bonds and one-half stock. The American Sheet Steel Co. absorbed 30 concerns and was capitalized at $52,000,000, one-half preferred and one-half common stock. The American Bridge Co. took over the rolling mills of the Pencoyd Iron Works and the New Jersey Steel & Iron Co., together with 24 bridge building plants. The Crucible Steel Co. of America, capitalized at $50,000,000, one-half each in common and preferred stock, absorbed 13 rolling mills and steel plants, the most important of which was the Park Steel Co., of Pittsburg. The American Iron & Steel Works, capitalized at $20,000,000, took over the Jones & Laughlins, Ltd., and other important interests. The tendency toward large consolidations culminated early in 1901 in the formation of the United States Steel Corporation, with a capitalization of $1,100,000,000, one-half preferred and one-half common stock, besides $304,000,000 in bonds issued for the purchase of the Carnegie interests. The companies comprising the organization are: American Steel Hoop, American Tinplate, American Sheet Steel, National Steel, National Tube, American Steel & Wire, Federal Steel, Carnegie interests, American Bridge Co. and the Lake Superior Consolidated Mines.

Iron Ore.—The production of iron ore in the United States during 1900 amounted to 26,815,185 long tons, the largest yearly output yet on record. The mines of Michigan, Minnesota and Wisconsin were developed to a remarkable degree and continue to supply the ores from which were made fully 80% of the total production of pig iron in the United States.

The imports of iron ore in 1900 amounted to 897,792 long tons, against 674,082 long tons in 1899, an increase of 223,710 tons or 33·2%. The imports last year were largely from Cuba; but a considerable quantity came from Spain, some from Newfoundland and some—the first of the kind—from Western Ontario. The exports of iron ore in 1900 were 51,460 tons, which compares

with 40,665 tons in 1899. Nearly all of this was Lake Superior ore for Canadian furnaces.

IRON ORE MINED AND CONSUMED IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

(Includes Spiegeleisen and Ferromanganese.)

District.	1898.	1899.	1900.
Lake Superior, shipments to furnaces	14,024,673	18,251,804	19,095,393
Southern States, shipments to furnaces	4,980,000	4,800,000	5,100,000
Other States, shipments to furnaces	1,678,500	2,240,000	1,758,000
Total mined in United States	20,683,173	25,291,804	25,917,393
Add decrease in stocks at Lake Erie docks	787,348		
Add importations	187,093	674,082	897,792
Total	21,657,614	25,965,886	26,815,185
Deduct increase in stocks at Lake Erie docks		750,000	600,000
Deduct exportation	31,579	40,665	51,460
Total consumption	21,626,035	25,175,221	26,073,725

Pig Iron.—The production of pig iron in the United States in 1900 and in previous years is given in the subjoined tables:

PRODUCTION OF PIG IRON IN THE UNITED STATES. (*g*) (IN TONS OF 2,240 LB.)

According to Fuel Used.	1897.	1898.	1899.	1900.
Anthracite	932,777	1,203,273	1,599,552	1,677,048
Coke	8,464,692	10,273,911	11,736,385	11,727,712
Charcoal	255,211	296,750	284,766	339,874
Charcoal and coke mixed				44,608
Tota's	9,652,680	11,773,934	13,620,703	13,789,242

Kind of Iron.	1898.		1899.		1900.	
	Tons.	%	Tons.	%	Tons.	%
Foundry and forge iron	3,437,337	29·2	4,213,124	30·9	4,517,437	32·8
Bessemer pig	7,337,384	62·3	8,202,778	60·2	7,943,452	57·6
Basic pig	785,444	6·7	985,033	7·3	1,072,376	7·8
Spiegeleisen and ferromanganese	213,769	1·8	219,768	1·6	255,977	1·8
Totals	11,773,934	100·0	13,620,703	100·0	13,789,242	100·0

States.	1895.	1896.	1897.	1898.	1899.	1900.
Alabama	854,667	922,170	947,831	1,033,676	1,083,905	1,184,337
Colorado	58,508	45,104	6,582	*a* 141,010	*a* 138,880	*a* 159,204
Connecticut	5,615	10,187	8,336	6,336	10,129	10,233
Georgia	31,034	15,593	17,092	13,762	*b* 17,835	*b* 28,984
Illinois	1,006,091	925,239	1,117,239	1,365,898	1,442,012	1,363,383
Kentucky	63,780	70,660	35,899	100,724	119,019	71,562
Maryland	10,916	79,472	193,702	190,974	234,477	290,073
Massachusetts	4,710	1,873	3,284	3,661	2,476	3,310
Michigan	91,222	149,511	132,578	147,640	134,443	163,712
Minnesota	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)
Missouri	27,518	12,548	23,883	(*c*)	(*c*)	(*c*)
New Jersey	55,502	59,153	95,696	100,681	127,598	170,262
New York	181,702	206,075	243,304	228,011	264,346	292,827
North Carolina	323	2,151			(*e*)	(*e*)
Ohio	1,463,789	1,196,326	1,372,889	1,986,358	2,378,212	2,470,911
Pennsylvania	4,701,163	4,024,166	4,631,634	5,537,832	6,558,878	6,365,935
Tennessee	248,129	248,338	272,130	263,439	346,166	362,190
Texas	4,682	1,221	6,175	5,178	5,803	10,150
Virginia	346,589	386,277	307,610	283,274	365,491	490,617
West Virginia	141,968	108,569	132,907	192,699	187,858	166,758
Wisconsin	148,400	*d* 158,484	*d* 103,909	*d* 172,781	*d* 203,175	*d* 184,794
Totals	9,446,308	8,623,127	9,652,680	11,773,934	13,620,703	13,789,242

(*a*) Production of Missouri included. (*b*) Production of North Carolina included. (*c*) Production included in Colorado figures. (*d*) Production of Minnesota included. (*e*) Production included in Georgia figures. (*f*) Production included in Wisconsin figures. (*g*) Statistics furnished by James M. Swank, of the American Iron and Steel Association.

According to the statement of the American Iron & Steel Association, while the production of pig iron in the United States was somewhat greater in 1900 than in 1899, the consumption was actually less, as shown in the subjoined table:

CONSUMPTION OF PIG IRON IN THE UNITED STATES. (IN LONG TONS.)

	1899.	1900.		1899.	1900.
Domestic production	13,620,703	13,789,245	Exports	228,678	286,815
Imported	40,393	52,565	Stocks unsold, Dec. 31	68,309	446,020
Stocks unsold, Jan. 1	415,333	68,309	Total deductions	296,987	732,835
Total supplies	14,076,429	13,910,116	Consumption	13,779,442	13,177,281

Blast Furnace Production.—The number of blast furnaces in activity January 1, 1901, was 232, with a weekly productive capacity of 257,801 long tons and a corresponding annual capacity of 12,500,000 tons, while those out of blast numbered 172 with a weekly capacity of 106,387 tons. On January 1, 1900, there were 280 furnaces in blast with a weekly capacity of 294,186 tons and a corresponding annual capacity of 15,000,000 tons. Considerable activity was manifested in the construction of new furnaces, there being 23 in course of erection by the following companies: Carnegie Steel Co., Ltd., 2 at Rankin Station, Pa.; American Steel & Wire Co., 1 at Neville Island, Pa., and 1 at Cleveland, Ohio; Jones & Laughlins, Ltd., 1 at Pittsburg, Pa.; National Steel Co., 1 at Newcastle, Pa., 2 at Mingo Junction, Ohio, and 1 at Youngstown, Ohio; Sharon Steel Co., 1 at Sharon, Pa.; Warwick Iron & Steel Co., 1 at Pottstown, Pa.; Joseph Wharton, 1 at Port Oram, N. J.; Columbus Iron & Steel Co., 2 at Columbus, Ohio; Globe Iron Co., 1 at Jackson, Ohio; Illinois Steel Co., 2 at South Chicago, Ill.; Iroquois Iron Co., 1 at Chicago, Ill.; LaFollette Coal, Iron & Railway Co., 1 at LaFollette, Tenn.; Roane Iron Co., 1 at Rockwood, Tenn.; Pioneer Mg. & Mfg. Co., 1 at Thomas, Ala.; Colorado Fuel & Iron Co., 1 at Pueblo, Colo.

Steel.—The production of steel in the United States in 1900 is given in the subjoined table:

PRODUCTION OF STEEL IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Kinds.	1895.	1896.	1897.	1898.	1899	1900.
Bessemer	4,909,128	3,919,906	5,475,315	6,609,017	7,586,354	6,684,770
Open-hearth	1,137,182	1,298,700	1,631,843	2,230,292	2,947,316	3,402,552
Crucible	67,666	62,500	65,600	89,747	128,500	131,250
Miscellaneous	858	900	1,750	3,801		
Total tons	6,114,834	5,582,606	7,174,508	8,932,857	10,662,170	10,218,572
Total metric tons	6,212,671	5,671,928	7,289,300	9,075,783	10,832,765	10,382,069

The production of Bessemer steel in the United States in 1900 was 6,684,770 long tons, against 7,586,354 long tons in 1899, showing a decrease of 901,584 long tons or 11·9% C. Of the production in 1900 Pennsylvania furnished 3,488,431 long tons, Ohio 1,388,124 long tons and Illinois 1,115,571 long tons. These three States furnished 86·3% of the total product. Practically the entire Bessemer steel output in 1900 was made by the acid process. One Robert Besse-

mer plant was operated and seven Tropenas plants produced steel castings during the year. The production of Bessemer steel rails by the producers of Bessemer steel ingots was 2,361,921 long tons in 1900, against 2,240,767 long tons in 1899, showing a gain of 121,154 long tons. Making allowance for the small quantity of rails produced from purchased blooms or re-rolled steel rails, 38·8% of the Bessemer steel ingots made in 1900 was consumed in the manufacture of rails. The exports of steel rails in 1900 reached 356,245 long tons or 15·1% of the total rail production. The use of heavier rail sections still continues and the increase in the production of light rails is due to the development of mining and lumbering enterprises and to activity in general construction work. The division of steel rails according to the weights per yard is separately reported by the American Iron & Steel Association in the subjoined table:

Weight per Yard.	1898.	1899.	1900.
	%	%	%
Heavy rails, over 85 lb.	23·2	25·9	25·5
Medium rails, between 45 lb. and 85 lb.	70·7	68·3	68·0
Light rails, less than 45 lb.	6·1	5·8	6·5
Total	100·0	100·0	100·0

Pennsylvania produced 1,195,225 long tons of rails, an amount slightly more than one-half of the total output. Adding the small quantity of iron rails still produced, together with that rolled from open-hearth steel, the total rail output for 1900 would equal approximately 2,400,000 long tons.

The subjoined table shows the production of rails as compared with that of Bessemer steel ingots, for the past six years.

Year.	Tons Ingots	Tons Rails.	Per Cent.	Year.	Tons Ingots	Tons Rails.	Per Cent.
1895	4,909,128	1,266,081	25·8	1898	6,609,017	1,955,427	29·6
1896	3,919,906	1,102,892	28·1	1899	7,586,354	a 2,240,767	29·5
1897	5,475,315	1,614,399	29·4	1900	6,684,770	a 2,361,921	35·3

(a) Not including rails made from purchased blooms or re-rolled rails.

The production of open-hearth steel in 1900 was 3,402,552 long tons, against 2,947,316 in 1899, an increase of 455,236 tons, or over 15% of the total; the basic process yielded 2,547,023 tons and the acid process 855,529 tons. The production of open-hearth steel in 1900 was derived from 92 works in 17 States, against 76 works in 14 States in 1899. The new States entering the list in 1900 were Delaware, Kentucky and Tennessee. The total production of open-hearth direct steel castings in 1900 (included above) amounted to 179,326 long tons, of which 41,094 tons were basic steel and 138,232 were acid steel. It is estimated that there were from 100,000 to 110,000 long tons of crucible steel ingots produced during 1900.

Tin Plate.—The production in long tons of finished tin plate (including dipping plants) is given by James M. Swank as follows:

Year.	Tons.	Year.	Tons.	Year.	Tons.
1891 (a)	999	1894	74,260	1897	256,598
1892	18,803	1895	113,666	1898	326,915
1893	55,182	1896	160,362	1899	360,875

(a) Last six months.

Changes in Iron and Steel Metallurgy.—There were no changes of marked importance in iron and steel metallurgy during 1900. Such changes as occurred were chiefly in the direction of improvements in economy of production and in the better handling of large quantities of material. The use of blast furnace gases for the production of power has extended rapidly in Germany and Belgium, where at the close of the year the engines thus operated reached a total of 35,000 horse power. In this connection, reference may be made to the special article by Dr. George Lunge, "The Utilization of Blast Furnace Gases for the Direct Production of Motive Power," page 164 of this volume. The study of the possible utilization of slag for various purposes has been continued, and the use of basic slag in the manufacture of cement and in making commercial fertilizers is extending. Among other improvements may be mentioned the establishment in Chicago of a plant for making steel castings by the Tropenas process and the successful application of the Monell open-hearth steel process at the Carnegie Works. The use of molybdenum, tungsten and vanadium in making special steels, and of nickel-steel for rails is being largely extended.

F. W. Taylor and Maunsel White have developed a process for the manufacture of a special steel for edged tools, and the Bethlehem Steel Co. equipped its factory last summer with cutting tools made from this steel. The Taylor-White process imparts to steel the property of retaining a great degree of hardness when heated to a very high temperature. With a tool prepared by this process steel may be cut at a speed so great that the point of the tool heats to redness while it continues to cut for several minutes with unimpaired swiftness. The practical speed at which these tools will run is from two to four times that of any other steels which the Bethlehem Co. tested in the course of exhaustive experimenting. The large investment which the company made in reconstructing its plant was more than repaid in the course of the year by the larger output and the saving in labor and cost through the increase in cutting speed of the machine tools throughout the shop. In some comparative tests of the Taylor-White process and Mushet steel, three tests were performed, two with steel and one with cast iron. In every case the depth of cut was 0·175 in. and the feed 0·058 in. The Taylor-White tool working on a 1·05% carbon steel, cutting 15 ft. per minute, showed no signs of distress after some 20 minutes' work. A Mushet steel tool failed under the same conditions in a few seconds. In the second test the specially-treated tool cut through 0·10% carbon steel at the rate of 150 ft. per minute for some minutes without injury, although the point of the tool was red hot. A Mushet tool ran 5 seconds under the same conditions. With a hard cast-iron, the Taylor-White tool ran for 16 minutes at the rate of 50 ft. per minute. The Mushet tool failed in 10 seconds. The Taylor-White process is applied to the tool to be treated after it has been machined or dressed, and while it improves every kind of self-hardening steel it is preferable to use steel of special composition which by a simple and rapid process of annealing may be worked into twist drills, chasers, inserted cutters and similar tools of complex shape. A result which must follow the introduction of the Taylor-White process will be the practical exclusion of the foreign brands of self-hardening steel which now supply over half the demand of America.

Arguments have been heard before the United States Supreme Court in the

suit between the Carnegie Steel Co. and the Cambria Steel Co., which involve the validity of the Jones Miner patent. The Carnegie Co. owns the Jones patent and seeks to enjoin the Cambria Co. from using a mixer or reservoir for molten metal, which is claimed to be an infringement of the patent. Contrary to general expectations the Supreme Court did not give a decision after hearing the arguments, but ordered a re-argument, which carries the case over to the December term of 1901, thereby leaving unsettled for the present a case of much importance to steel makers.

The report by Prof. Henry M. Howe on "Iron and Steel Metallurgy at the Paris Exposition, 1900," given later in this section, reflects in a measure the progress that has been made in the different branches of the industry and reference may be made thereto for specific details.

The Iron Markets in 1900.

The general course of the American iron market in the past year may thus be summarized: A period of high prices; a sharp break in quotations accompanied by a failing off in business; a partial recovery in prices; large exports throughout the year; at the end of the year an encouraging volume of business. Apart from the companies, or trusts mentioned earlier in this section, other companies were formed to compete with the combinations, chiefly in the production of nails, wire, tin plates, tubes and sheet steel. A contest between the railmakers and the railroads delayed the making of orders for rails in most cases until December.

Alabama.—Generally speaking, the year 1900 was a good one for the iron interests in Alabama. The furnace men were steadily busy and cases of financial embarrassment were infrequent. Beginning with September there was a notable increase in export business, which during the autumn amounted to 111,996 tons. The end of the year found the furnaces making iron to their fullest capacities, and the railroads kept on the move to handle the product, with quotations firm and tending toward a rise.

The following table contrasts the prices of pig iron at Birmingham for the month of January, 1900, with the closing prices for December, 1900:

	January, 1900.	December, 1900.		January, 1900.	December, 1900.
No. 1 Foundry	$18·50	$11·50 @ $12·50	Gray Forge	$15·75 @ $16·00	$9·55 @ $9·80
No. 2 Foundry	$17·58 @ $17·83	19·50 @ 11·50	No. 1, soft	$18·50	11·50 @ 12·50
No. 3 Foundry	16·66 @ 17·00	10·65 @ 10·50	No. 2, soft	17·66 @ 17·75	10·50 @ 11·50
No. 4 Foundry	16·08 @ 16·33	9·50 @ 9·94			

Chicago, Ill.—The year 1900 was in many respects a quiet one, yet, taken as a whole, it brought satisfactory returns to the manufacturers of iron and steel. The total tonnage handled was not so large as that of 1899, but it was beyond the tonnage of any other year. The highest point of the market, in nearly every commodity, was at the opening of the year, and there was an almost constant decline in values from early in the year to November, when prices stiffened again decidedly. In November, and in December until just before the holidays, business was excellent, and the year closed with order books filled for the ensuing six months. During the year the furnaces and mills in the Chicago district increased their capacity largely, through improvements and additions.

AVERAGE MONTHLY PRICES OF IRON AND STEEL AT CHICAGO IN 1900.

Month.	Lake Superior Charcoal Iron.	Northern No. 2 Foundry.	Southern No. 2 Foundry.	Bar Iron.	Rails.	Plates.	Billets.
January.....	$25·50	$24·50	$21·85	$46·50	$35·00	$52·50	$35·50
February ...	25·50	24·25	21·85	46·00	35·00	50·00	35·00
March.....	25·50	23·75	21·85	46·00	35·00	45·25	35·00
April	25·25	23·25	21·70	43·50	35·00	42·00	35·00
May.....	24·50	22·00	21·35	41·00	35·00	38·75	30·00
June.....	23·25	20.25	20·00	36·00	35·00	32·75	29·00
July.....	22·00	17·75	18·00	28·25	35·00	28·00	24·00
August.....	20·00	15·50	15·40	25·25	35·00	25·00	19·00
September..	18·10	14·50	14·85	26·00	32·75	26·00	19·00
October	17·60	14·00	14·00	26·00	26·00	25·00	19·00
November ..	16·50	14·25	14·25	27·25	26·00	29·25	20·25
December...	18·50	14·60	14·60	27·50	26·00	30·75	20·75
Average for the Year 1900	$21·85	$19·05	$18·31	$34·94	$32·56	$35·44	$26·79

Cleveland, Ohio.—The year 1900 was an exceptionally poor year in the Cleveland iron ore market. But little business was done at the foundry iron furnaces after July, when the Valley furnaces went out of blast. The Bessemer furnaces raked down their fires in September, and the year closed with all the furnaces idle. In finished material of all grades the market fluctuations were great, but prices had become steadier at the end of the year.

IRON ORE SHIPMENTS FROM UPPER LAKE PORTS. (IN TONS OF 2,240 LB.)

Ports.	1898.	1899.	1900.	Ports.	1898.	1899.	1900.
Escanaba.....	2,803,513	3,720,218	3,436,734	Duluth.....	2,635,462	3,509,965	3,888,986
Marquette.....	2,245,965	2,733,596	2,661,861				
Ashland	2,391,088	2,703,447	2,633,687	Total by Lake.....	13,655,432	17,901,358	18,570,315
Two Harbors.....	2,693,246	3,973,733	4,007,294	Rail shipments.....	374,250	350,446	489,078
Gladstone.....	335,955	381,457	418,854				
Superior.....	550,403	878,942	1,522,899	Total shipments.....	14,029,683	18,251,804	19,059,393

SHIPMENTS OF LAKE SUPERIOR IRON ORE BY RANGES. (IN TONS OF 2,240 LB.)

Year.	Marquette.	Menominee	Gogebic.	Vermilion.	Mesabi.	Michipicoten. (Canada.)	Totals.
1896...	2,603,839	1,560,467	1,799,971	1,088,090	2,882,079		9,934,446
1897.....	2,715,035	1,937,913	2,258,236	1,278,481	4,280,873		12,469,638
1898.....	3,195,039	2,527,274	2,498,462	1,265,142	4,613,766		14,029,683
1899.....	3,757,010	3,301,052	2,795,856	1,771,502	6,626,384		18,251,804
1900.....	3,457,522	3,261,221	2,875.295	1,065,820	7,809,535	62,000	19,121,393
Totals from opening.	59,592,793	34,015,979	31,216,635	15,191,180	31,400,077	62,000	171,418,984

IRON ORE RECEIPTS AND STOCKS AT LAKE ERIE PORTS. (IN TONS OF 2,240 LB.)

Ports.	Receipts at Ports.				Stock on Docks Dec. 1.			
	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Toledo	416,438	414,012	792,348	645,147	194,644	146,568	186,422	242,375
Sandusky.....	79,792	136,200	87,499	154,542	84,786	48,500	23,184	95,111
Huron.....	198,231	126,755	263,600	321,914	230,029	139,982	164,480	211,377
Lorain	355,188	536,086	1,112,946	1,090,235	317,509	324,034	337,822	251,838
Cleveland	2,456,704	2,645,318	3,223,582	3,376,644	1,478,355	1,175,970	1,200,806	1,337,445
Fairport	1,008,340	912,879	1,241,013	1,085.554	825,312	719,794	692,147	611,717
Ashtabula.....	3,001,914	2,684,563	3,341,526	3,700,486	1,835,694	1,732,671	1,902,598	1,811,459
Conneaut.....	495,327	1,404,169	2,320,696	2,556,631	360,895	288,101	468,808	630,514
Erie.....	1,311,526	1,092,364	1,309,961	1,240,715	484,871	439,167	361,335	480,734
Buffalo..... Tonawanda...	797,446	1,075,975	1,530,016	1,616,919	111,660	121,620	192,681	232,109
Totals	10,120,906	11,028,321	15,222,187	15,797,787	5,923,755	5,136,407	5,530,283	5,904,670

Pittsburg.—The year 1900 was remarkable in the fluctuations and uncertainties in prices in the iron and steel trade in the Pittsburg district. It opened quietly and with decided indications of strength in almost every line of finished iron and steel products. Several thousand tons of Bessemer pig iron were sold during January at $25. Pittsburg and Bessemer steel billets brought $35 a ton. The minimum price of steel bars was 2·25c., and tank plates brought about 2·40c. Sheet, the only line in which the same price practically was maintained throughout the year, was quoted in January, for No. 28 gauge, at 2·95 @3c., and this was the price in December. Galvanized sheets actually showed an improvement in prices in December over the quotations at the opening of the year. Prices held firm during February, but they declined in March, and in April Bessemer steel billets fell to $33 a ton, and tank plates dropped to 1·90c. A meeting of steel interests was held in May, at which the nominal price of $35 for Bessemer steel billets was reaffirmed, but, despite this fact, in the latter part of May sales were made as low as $28. Tank plates went down to 1·60c., and steel bars sold as low as 1·75c., Pittsburg. It is now known that the market quotations given out by producers, particularly during the first half of the year, were not according to the actual sales made. Steel manufacturers earnestly endeavored to maintain a high range of prices, for the reason that it is difficult to sell material on a falling market. At the close of the first half year extravagant demands of the Amalgamated Association of iron, steel and tin workers for increase in wages in every branch of the iron, steel and tinplate industries caused the closing of all the union mills. Most of the mills were idle for nearly three months before all the wage scales had been arranged and operations resumed. The second half of the year opened with the markets in a very unsatisfactory condition. At a meeting of the Bessemer Furnace Association the price was fixed at $20 Pittsburg. The steel makers also held a meeting and fixed a price of $28 for Bessemer steel billets to supersede the former figure of $35, which had become wholly nominal, but before the end of the month billets could be bought as low as $24. Steel bars fell to 1·45c. this month; and tank plates to 1·40c. There was a further decline in July of Bessemer pig iron to $17 Pittsburg; of tank plates to from 1·10c.@1·15c., and of steel bars to from 1·05c.@1·25c. Early in August steel bars sold considerably below cost, as low even as 0·87c. in exceptional cases. In September Bessemer pig iron dropped to a price of from $14@$15 delivered in Pittsburg. There was little change in the iron and steel markets at the opening of the fourth quarter, and prices of finished material were generally firm. Bessemer pig iron had declined to $13·25 Pittsburg. But little business was done in Bessemer steel billets, and the price was as low as $16·25, the lowest point reached during the year. There was a reaction before the close of October, and sales were made at $17·50, delivered at Pittsburg. Soon after the result of the Presidential election was known there was a noticeable improvement in nearly all lines. The principal Bessemer steel billet producers convened and established a price of $19·75 for billets, delivered at Pittsburg. Plates were advanced $2 a ton, making the price for tank plates 1·35c., and steel bars were increased to 1·25c. Before the

end of November the price of Bessemer pig iron advanced to $14, delivered at Pittsburg. These prices continued to the close of the year.

The subjoined table shows the December prices of iron and steel products for the past three years:

DECEMBER PRICES FOR IRON AND STEEL AT PITTSBURG.

	1898.	1899.	1900.		1898.	1899.	1900.
Bessemer	$10·80	$25·00	$13·90	Billets	16·50	37·00	19·75
No. 1 Foundry	11·10	24·00	13·00	Billet Ends	11·00	24·00	18·00
No. 2 Foundry	10·75	23·25	12·50	No. 1 Scrap	12·00	24·00	17·00
Mill Iron	10·65	21·50	13·25	Steel Rails	17·50	37·00	26·00
White Iron	9·25	20·00		Bar Iron	1·18	2·15	1·40
Mottled Iron	9·30	20·50	13·50	Iron Nails	1·30	2·50	2·05
Silvery, No. 1	13·00	27·00	16·00	Wire Nails	1·50	2·95	2·20
Charcoal, No. 1 Foundry	16·00	27·00	16·00	Coke at Ovens (furnace coke)	1·50	3·00	1·75
No. 2 Foundry	15·50	26·00	15·50	Ferromanganese, 80%.	50·00	100·00	62·50
Cold Blast	21·50	28·00	16.50	Old Iron Rails	14·00	30·00	22·00
Warm Blast	15·25	27·00	16·00	Old Steel Rails	10·00	23·00	17·00
Muck Bar	18·85	33·00	24·00				

Production of Pig Iron and Steel in the World.

The total world's production of pig iron in 1900 was 40,968,980 metric tons, an increase of 113,362 metric tons, or 0·28% over the previous year, while the production of steel amounted to 27,182,347 tons, showing an increase of 62,991 tons, or 0·23%. A comparison of the relative production of pig iron and steel during the past few years shows that the pig iron product is being more and more converted into steel, a condition due to the superiority of the latter as a structural material and to the continued cheapening of its manufacture. In other lines also steel is replacing cast iron, more particularly in the construction of large engines, locomotives and cars. The continued industrial activity is naturally reflected in the iron and steel trade, and there will be doubtless an increased production in some of the foreign countries in 1901, as well as in the United States. The statistical diagram which is given later in this section shows very clearly the relative positions occupied by the chief producers of iron and steel during the past 25 years. Of the world's production of pig iron in 1900 the United States made 34%, the United Kingdom 22% and Germany 20%, a total of 76% of the entire output for the year. The steel production and percentages in 1900 were: United States 38%, United Kingdom 17% and Germany 24%, a total of 79% of the world's supply. During the past decade the United States and Germany have greatly increased their production of steel, while the United Kingdom, occupying the third position on the list of producers, has not materially advanced. Assuming an average yield of 50% of pig iron from the ore charged into the furnace, the total production of pig iron in 1900 involves the mining and handling of about 80,000,000 tons of iron ore.

Belgium.—The total production of pig iron in Belgium in 1900 was 1,018,507 metric tons, against 1,024,576 in 1899, showing a decrease of 6,069 tons, 0·6%. This includes foundry, forge and steel pig. The total production of steel in 1900 was 654,857 tons, against 731,249 in 1899, a decrease of 76,392 tons, or 10·7% over 1899.

Production of Pig Iron and Steel in the World.

France.—The pig iron production in 1900 was 2,699,494 metric tons, an increase of 121,094 tons, or 4·7% over the production in 1899. The production of all kinds of steel during 1900 amounted to 1,660,118 metric tons (as against 1,530,832 tons in 1899), which was divided as follows: Bessemer steel ingots, 954,261 tons; open-hearth steel ingots, 669,787 tons; miscellaneous, 36,070 tons. These figures show an increased production in all branches.

PRODUCTION OF PIG IRON AND STEEL IN THE PRINCIPAL COUNTRIES. (IN METRIC TONS.)

Year.	Austria-Hungary.		Belgium.		Canada.	France.		Germany.	
	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron.	Pig Iron.	Steel.	Pig Iron.	Steel.
1896	1,130,000	*a* 520,000	932,780	598,755	47,635	2,333,702	1,159,970	6,360,982	4,297,447
1897	1,205,000	553,000	1,024,666	616,604	49,497	2,472,143	1,281,595	6,888,087	5,091,294
1898	1,250,000	605,500	982,748	653,130	69,248	2,525,075	1,433,717	7,402,717	5,734,307
1899	1,323,999	*a* 660,000	1,024,576	731,249	95,582	2,578,400	1,529,182	8,029,305	6,290,434
1900	*a*1,350,000	*a* 675,000	1,018,507	654,827	87,612	2,699,424	1,624,048	8,351,742	6,645,869

Year.	Italy.		Russia.		Spain.		Sweden.	
	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron.	Steel.
1896	11,280	59,500	1,629,810	*a*625,000	246,326	104,577	466,400	250,600
1897	12,500	57,250	1,857,000	821,000	282,171	121,100	533,800	268,300
1898	12,850	58,750	2,228,850	1,095,000	261,799	112,605	492,700	263,700
1899	19,218	58,550	2,670,937	1,321,328	299,765	117,650	497,727	272,480
1900	*a* 20,000	*a* 58,000	*a* 2,850,000	*a* 1,500,000	294,118	150,634	520,600	291,900

Year.	United Kingdom.		United States.		All Other Countries.		Totals.	
	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron. (*a*)	Steel. (*a*)	Pig Iron.	Steel.
1896	8,700,220	4,306,211	8,761,197	5,366,518	395,000	290,000	31,015,302	17,581,131
1897	8,930,086	4,559,736	9,807,123	7,289,300	450,000	310,000	33,513,073	20,979,179
1898	8,819,968	4,639,042	11,962,317	9,075,783	545,000	355,000	36,658,272	24,365,502
1899	9,454,204	4,933,010	13,838,634	10,832,765	625,000	400,000	40,457,341	27,119,356
1900	9,052,107	*a* 4,800,000	14,099,870	10,382,069	625,000	400,000	40,968,980	27,182,347

(*a*) Estimated.

Germany.—The production of pig iron in Germany, including Luxemburg, is reported by the Association of German Iron and Steel Makers in the following table:

Description.	1898.		1899.		1900.		Changes.
	Metric Tons.	%	Metric Tons.	%	Metric Tons.	%	Metric Tons.
Foundry iron	1,301,768	17·6	1,424,732	17·7	1,487,929	17·8	Inc. 63,197
Forge iron	1,564,149	21·1	1,663,571	20·7	1,587,194	19·0	Dec. 76,377
Bessemer pig	534,674	7·2	516,950	6·5	495,790	5·9	Dec. 21,160
Thomas (basic) pig	4,002,126	54·1	4,424,052	55·1	4,780,829	57·3	Inc. 356,777
Totals	7,402,717	100·0	8,029,305	100·0	8,351,742	100·0	Inc. 322,437

The total increase in 1900 of 4·0% over the product in 1899 shows a decline of 4·5% from the increase in the preceding year. During the past nine years there has been no retrograde movement; each year showing a gain over the preceding one. There were no important changes in the divisions of the output, the production of basic pig showing the greatest variation with an increase of 2·2%. This is a natural result of the high phosphorus content of nine-tenths and more of the native ores.

The production of steel in Germany, as reported by the Association of German Iron and Steel Makers, is given in the subjoined table:

	1898.		1899.		1900.	
	Metric Tons.	%	Metric Tons.	%	Metric Tons.	%
Basic converter	3,606,737	62·9	3,973,225	63·2		
Basic open-hearth	1,459,159	25·4	1,693,825	26·9		
Total basic	5,065,896	88·3	5,667,050	90·1		
Bessemer	668,411	11·7	623,384	9·9		
Totals	5,734,307	100·	6,290,434	100·	6,645,869	

There was an increase in the total production of Bessemer and open-hearth steel ingots in 1900, the amount for 1899 and 1900 being respectively 6,290,434 metric tons and 6,645,869 tons. According to the official report of the Government, the production of wrought iron in finished forms—bars, plates, etc.—was 929,832 tons, against 1,103,665 tons in 1900, showing a decrease of 173,833 tons, or 15·7%, from 1900. The total output of steel in all finished forms—as rails, plates, bars, shapes, structural material, etc.—was 4,799,196 tons in 1900, while in 1899 it was 4,793,523 tons. Statistics of the division into Bessemer and open-hearth steels as well as into acid and basic classes are not available at the time of publication.

Russia.—The statistics for the production of iron and steel in Russia in 1900 are not yet available. The output in 1899 was 2,670,937 metric tons of pig iron and 1,321,328 tons of steel. The production in 1900 will doubtless exceed these figures.

Spain.—The total production of iron ore in 1900, reported by the *Revista Minera,* was 8,480,246 metric tons, against 9,397,733 tons in 1899, a decrease of 917,487 tons, or 9·8%. Two-thirds of this production—5,317,920 tons—was from the mines in the Province of Vizcaya, while 1,117,017 tons were mined in Santander. The domestic consumption of iron ore was 656,976 tons, or 7·7% of the total ore mined, the remainder 92·3% being exported. The products of iron and steel are given in the following table:

	1898.	1899.	1900.	Changes from 1899.
Pig iron	262,497	295,840	294,118	Dec. 1,722
Wrought, or puddled iron		66,568	65,045	Dec. 1,523
Bessemer steel ingots	54,500	68,300	91,586	Inc. 23,286
Open-hearth ingots	58,105	49,350	59,048	Inc. 9,698
Finished iron and steel	154,910	173,566	212,121	Inc. 38,555

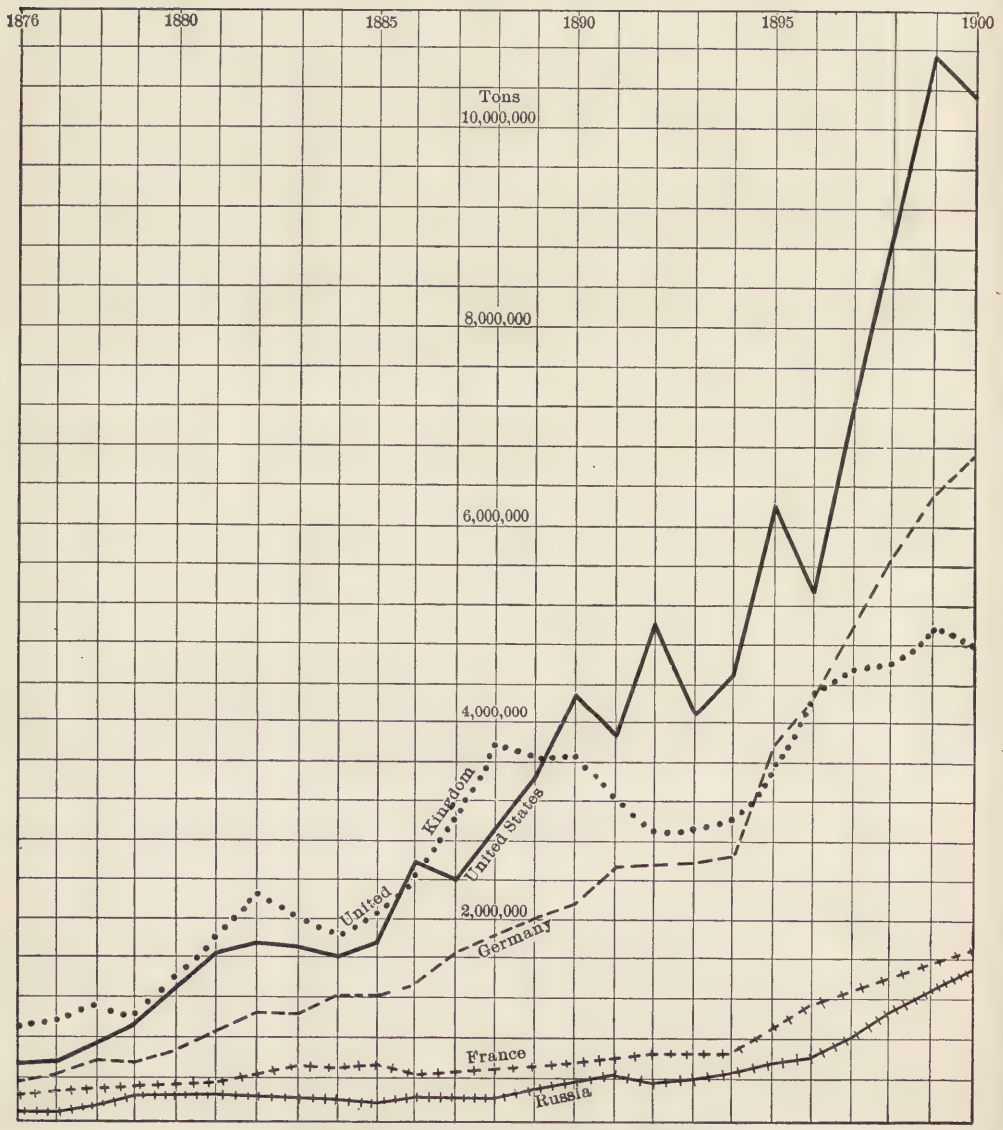
Of the pig iron production but a small proportion, 19,000, was made with charcoal, the principal fuel being coke. The exports of pig iron in 1900 were 27,169 tons, a decrease of 20,750 tons from 1899.



THE WORLD'S PRODUCTION OF PIG IRON IN METRIC TONS.

The amount in metric tons and the destination of the exports of iron ore from Spain for the past four years are given in the subjoined table:

Destination.	1897.	1898.	1899.	1900.	Changes from 1899.
Great Britain	5,091,057	4,748,557	6,224,229	5,489,323	Dec. 739,906
Germany	1,058,694	1,193,924	1,544,449	1,441,128	Dec. 103,321
France	435,972	399,424	443,818	450,746	Inc. 6,928
Belgium	224,776	201,693	254,860	247,351	Dec. 7,509
United States	59,243	5,792	132,422	195,964	Inc. 63,542
Other countries	14,876	8,670	13,359	3,758	Dec. 9,601
Totals	6,884,588	6,558,060	8,613,137	7,823,270	789,86



THE WORLD'S PRODUCTION OF STEEL IN METRIC TONS.

Sweden.—The production of pig iron in 1900 was 520,600 metric tons, an increase of 22,873 tons, or 4·6% above the production in 1899. The Bessemer and steel ingots produced were 91,500 tons, being 398 tons less than 1899. There was an increase of 11%, or 21,043 tons in the amount of open-hearth steel ingots produced, the figures for 1900 and 1899 being respectively 200,400 and 179,357 tons. The production of blooms and billets was 189,500 tons, a decrease of 5,831 tons, or 3% above the production in 1899.

United Kingdom.—The production of pig iron in 1900 as reported by the British Iron and Steel Trade Association was 9,052,107 metric tons (8,908,570 long tons), against 9,454,204 metric tons in 1899, a decline of 5·8%. The 1900 output was divided into forge and foundry iron, 4,108,350 long tons (46·1%); Bessemer pig, 3,636,839 long tons (40·8%); basic pig 924,987 long tons (10·4%); spiegeleisen and ferromanganese 238,394 long tons (2·7%). The loss was mostly in Bessemer pig, but the foundry and forge iron showed a decrease of 3·5%. In 1899 steel pig of various classes constituted 54·2% of the total make, while in 1900 they formed 53·9%. This is a much lower proportion than in the United States, where in 1900 the proportion of steel pig was 65·4% of the total; or Germany, where it was 63·2%. The lower proportion in the United Kingdom is due to the greater adherence of the iron makers to wrought or puddled iron. The total stocks on hand at the end of the year was 456,419 long tons, showing a reduction of 277,570 tons during the year. The exports in 1900 were 1,428,549 tons, while 175,393 tons were imported, giving a net export of 1,203,903 tons. The approximate consumption of pig iron in the United Kingdom in 1900 was 7,982,237 long tons. The production of steel in the United Kingdom is detailed in the subjoined table:

Variety.	1898.		1899.		1900.		Changes from 1899.
Open-hearth:	Long Tons.	Per cent.	Long Tons.	Per cent.	Long Tons.	Per cent.	Tons.
Acid steel	2,590,512	92·3	2,735,563	90·3			
Basic steel	216,088	7·7	294,688	9·7			
Total open-hearth	2,806,600	100.0	3,030,251	100·0			
Bessemer:							
Acid	1,255,252	71·3	1,307,696	71·6	1,253,903	71·9	Dec. 53,793
Basic	504,134	28·7	517,378	28·4	491,101	28·1	Dec. 26,277
Total Bessemer	1,759,386	100·0	1,825,074	100·0	1,745,004	100·0	Dec. 80,070
Total steel	4,565,986		4,855,325				

Details of open-hearth steel production as well as of that of wrought iron are not available at the time of publication.

Every Bessemer steel district showed a diminished productior in 1900, except West Cumberland. The Bessemer process continues to produce in Great Britain a larger quantity of basic steel than the open-hearth. In all, six works made basic steel by the Bessemer system, and more than one-half of the total output is produced in the Cleveland district, where two works carry on the process. The number of Bessemer converters in the United Kingdom last year was 76, of which 14 were idle. The average yearly output per converter was therefore 28,145 tons of steel.

The chief descriptions of finished Bessemer steel, which are reported to the association are given in the subjoined table:

FINISHED BESSEMER STEEL PRODUCTION IN THE UNITED KINGDOM. (IN TONS OF 2,240 LB.)

	1899.	1900.		1899.	1900.
Rails	838,148	759,814	Blooms and billets	355,335	280,220
Plates and angles	158,878	96,108	Bars	214,951	221,795
Sleepers	35,743	27,291	Total	1,604,055	1,385,228

A Report on Iron and Steel Metallurgy at the Paris Exposition, 1900.

By Henry M. Howe.

The Fagersta Exhibit.—This exhibit, prepared by J. A. Brinell, of the Fagersta works in Sweden, was by far the most interesting and instructive of the metallurgical matters shown at Paris. A full account of it is expected to appear in the *Jernkontorets Annaler*. The following are among its more interesting features:

(1) The results of an important investigation into the relation between the composition of steel and the position of the blowholes. These results are described later in this report.

(2) A description of Mr. Brinell's rapid method of determining the hardness, tensile strength, elastic limit, and ducility of steel by noting the deformation caused by pressing into it a hard steel ball under given pressure.

(3) The increment of hardness caused in three different kinds of steel by sudden cooling in each of 10 different liquids. Among his results, which are given in Fig. 1, we note that when an energetically cooling liquid is used, the increment of hardness is greater in case of the 0·44% C steel than in case of the 1·17% C steel, though it is probable that the absolute hardness of the latter remains much the greater of the two.

(4) The relation between the composition and tensile strength of steel, as shown by applying the ball test to some 1,500 different specimens of steel.

(5) The influence of 30 different heat treatments on each of 13 different steels, the carbon-content of which varies from 0·09 to 1·17%.

(6) The best temperature for hardening each of 13 different steels.

(7) The properties of sulphur steel, of the following composition:

Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
%	%	%	%	%
0·31	0·126	0·94	0·033	0·15
0·46	0·369	1·06	0·055	0·56

Sulphur Steel.—The properties of this remarkable material remind us of those of wrought iron. Like wrought iron it readily develops a fibrous fracture during rupture; in line with this is the fact that it is used for railroad axles, for which, even in this country, many important conservative railroads still prefer wrought iron to steel. Other peculiarities are that it is cut easily to shape by machine tools, and that it is not made coarse and brittle by overheating, as common steel is. It is an open secret that pyrites has for several years been

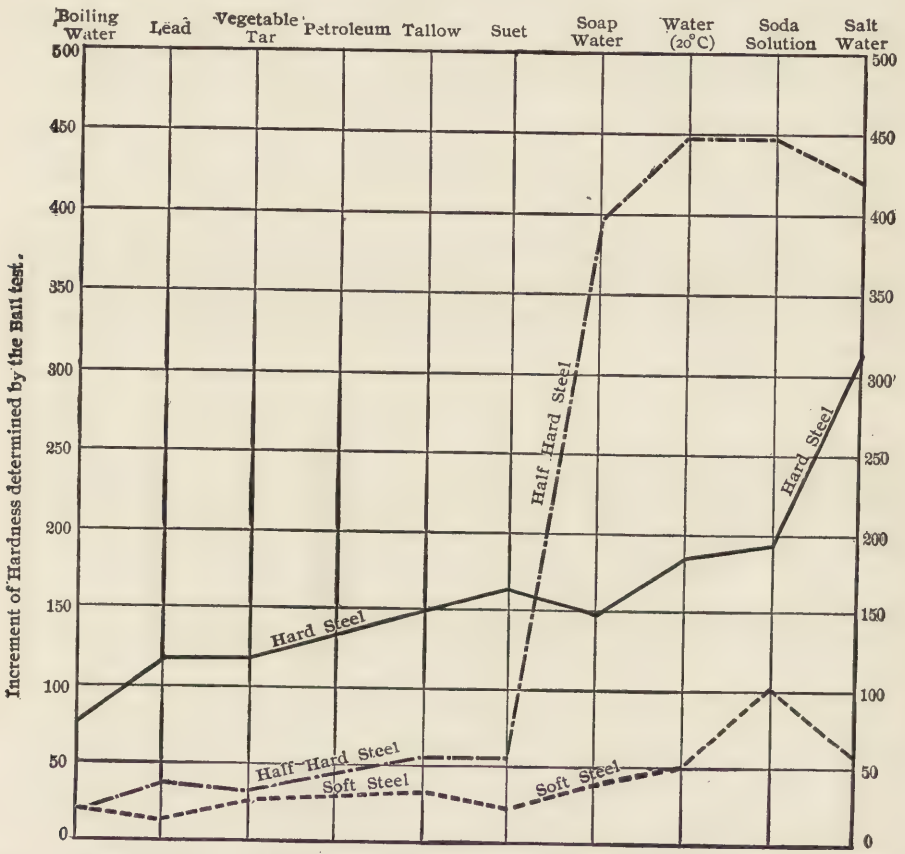


FIG. 1.—INFLUENCE OF DIFFERENT QUENCHING MEDIA ON THE HARDNESS OF DIFFERENT OPEN-HEARTH STEELS, BY J. A. BRINELL.

Composition of Steel: (soft) C, 0·09%; Si, 0·005%; Mn, 0·10%; P, 0·026%; S, 0·020%; (half hard) C, 0·44%; Si, 0·275%; Mn, 0·46%; P, 0·029%; S, 0·020%; (hard) C, 1·17%; Si, 0·313%; Mn, 0·21%; P, 0·027%; S, 0·010%.

added to low carbon steel at several important American steel works, especially for making a steel which is easily "machined," *i.e.*, easily cut by machine tools.

The Best Temperature for Hardening.—Mr. Brinell has determined approximately the best temperature for hardening several different classes of steel, by noting what hardening temperature gives the finest grain to the fracture of the hardened steel. For three steels containing from 0·16 to 0·25% C,

this temperature was 900°C. (1,652°F.); for six steels containing from 0·31 to 0·79% C, it was 850°C. (1,562°F.); for steel containing 0·94% C, it was 800°C. (1,472°F.) and for steel containing 1·17% C, it was 850°C. (1,562°F.).

Blowholes in Steel Ingots.—In passing from the molten to the solid state, steel like so many other liquids is prone to evolve gas, which forms bubbles or "blowholes" in the resulting castings. These blowholes may be very injurious, especially if they lie near the surface, because in this case their sides become coated with a thin layer of iron oxide, due to the diffusion of the atmospheric oxygen; and this iron oxide prevents the sides of the blowholes from welding together when the ingots later are rolled or hammered. Deep-seated blowholes may be harmless, especially if the steel is to be rolled or hammered, because their sides being free from any coating of oxide, weld firmly together, so that the blowholes may thus be obliterated. Indeed, a slight porosity, due to an incipient formation of blowholes, is desirable in case of steel which is to be hammered or rolled; because but for such porosity a considerable shrinkage cavity or pipe would form in the axis of the ingot, which thereby would be materially damaged. Both manganese and silicon tend to prevent the formation of blowholes, and also influence their position; and Mr. Brinell finds that a given percentage of silicon in this respect is equivalent to 5·2 times that of the same quantity of manganese; so that, for the purpose of expressing their joint influence, we may use the formula Mn+5·2 Si, in which Mn and Si refer to the percentage of manganese and silicon respectively which remain in the solid steel.

From a graphical examination of some 600 cases he deduces a law which expresses the relation between the quantity of manganese and silicon remaining in the steel, and the quantity and position of the blowholes.

His law is expressed by the following table:

Mn + 5·2 × Si.	Name of Structure.	Position, etc., of Blowholes.	Quality of the steel as regards blowholes and pipes.
2·05 %	*A*	No blowholes, but a small pipe.	Injured by the pipe.
1·66 %	*B*	No visible blowholes, no pipe.	Just compact enough. Excellent.
1·16 %	*C*	External blowholes, no pipe.	Injured by the external blowholes.
0·50 %	*D*	Fewer blowholes and somewhat deeper seated.	Blowholes still harmfully near the surface.
0·28 %	*E*	The blowholes are very deep seated.	Excellent.
Cast too hot.	*O*	Many external blowholes and a pipe.	Injured by the external blowholes.

Note.—Structure *O* is due, not to any special proportion of manganese and silicon, but to casting at too high a temperature.

To sum this up, the only good types are *B*, free both from considerable blowholes and from pipe, and with the Mn+5·2 Si=1·66%; and *E*, with blowholes abundant but deep-seated and harmless, and with Mn+5·2 Si=0·28%. The intermediate types are injured by having blowholes near the surface. While this same principle applies to conditions other than the particular ones which exist at Mr. Brinell's works at Fagersta, the actual percentage of manganese and silicon should be varied somewhat to meet different sets of conditions. In general either a higher casting-temperature, or a smaller cross-section of the ingots, or

the use of hot or that of thin walled molds, calls for a smaller quantity of silicon and manganese. Finally, Mr. Brinell finds that an addition of 0·0184% of aluminum, is approximately equivalent to the presence of manganese and silicon in the proportion Mn+5·2 Si=1·66%, *i.e.*, it unaided gives rise to type *B*. Naturally, little or none of this aluminum remains in the steel.

Alloy Cast Irons.—The exhibit of the "Hauts fourneaux de Marseille," Marseilles, France, is of interest as showing the range of composition of these special pig irons, all of which, to judge from the description, are made in the iron blast furnace.

They include (1) spiegeleisen with from 10 to 20% Mn; (2) ferromanganese with from 30 to 87% Mn; (3) ferrosilicon with from 10 to 17% Si and 1 to 3% Mn; (4) silicospiegel with from 10 to 14% Si and 16 to 20% Mn; and (5) ferrochrome with from 20 to 60% Cr.

"Draft" Fluid Compression of Steel Ingots.—In the common or Whitworth method of closing the pipes and blowholes in a steel ingot by strong pressure applied to it while solidifying, the pressure is applied to the top of a cylindrical ingot. If not compressed the ingot would contract both longitudinally and transversely during and in virtue of its cooling; and the mold simultaneously would expand in virtue of its heating through the heat which it receives from the ingot. The transverse contraction of the ingot draws it away from its mold, and the transverse expansion of the mold draws it away from the ingot. There is thus a double tendency to leave the sides of the ingot unsupported by the walls of the mold. The Whitworth system compresses the ingot lengthwise, and shortens and bulges it enough to compensate both for its own lengthwise and transverse contraction and for the expansion of the mold. In thus bulging the ingot acts like a cylinder of soft india rubber in part, but only in part. For, in passing from the molten to the solid state, the metal passes through an intermediate mushy state, when it has already lost the mobility of the molten state, and has not yet acquired the ductility of the solid state. It is while passing through this state that metallic castings tend to pull themselves asunder; and in this stage our bulging ingot tends to act like an unhooped barrel strongly compressed lengthwise, and to crack lengthwise as the staves of our barrel yawn apart. This splitting doubtless lessens very greatly the power needed for compressing the ingot, for the shell of the ingot when thus split should offer much less resistance to lengthwise compression than it would if it were an unbroken annular column. A disadvantage of this is that, when these rifts open through the shell of the ingot, the still molten central metal near the axis of the ingot, which has been enriched in carbon and phosphorus by segregation, is forced through these rifts to the surface, where it forms longitudinal ribbons of composition different from the rest of the crust. But for this extrusion, the segregated impurities would remain in the axis; if they remained there permanently they would be relatively harmless for most purposes, because they would be near the neutral axis; and in many cases they would be removed when the compressed ingot was finally bored out along its axis. In short the bulging of the ingot leads to cracking, which is beneficial in that it lessens the power needed for compression, but harmful in that it

allows the extrusion of the segregated axial metal: and this bulging is due to the tendency of the ingot to draw away from its mold. This drawing away and its consequences are avoided by the St. Etienne "Draft-Compression" process (Procédé de Compression par Tréfilage, Fonderies, Forges et Aciéries de Saint-Etienne, St. Etienne, France). In this, the ingot to be compressed is cast as the frustum of a slightly tapering cone, in a conical mold; and is then driven along the tapering mold by means of pressure applied to its base. Just as when we drive a tapered plug into a tapered hole, the radial pressure against the sides of the hole is very great; so here the centripetal radial pressure of the sides of the mold against the walls of the ingot is very great; a moderate pressure applied to its base creates an enormous pressure along its sides, buckling them in and forcing the metal centripetally, to fill up the pipe as fast it tends to form. A critical discussion of the relative merits of this system and those of Whitworth and S. T. Williams* would be beyond the scope of this report. But we may note that the draft compression, if properly applied,† should avoid the extrusion effect which is to be expected in the Whitworth process, and also in the Williams process if applied to large ingots, and that it should not need by any means so great pressure applied from without to the end of the ingot as the Whitworth system, for in the draft process the increase in the radial pressure due to the tapering should outweigh the increase of resistance due (1) to the tapering itself, (2) to the ingot-walls remaining unbroken instead of splitting as in the Whitworth process, and (3) to the resistance of the solid base of the ingot to radial compression. But the pressure needed should be much greater than in the Williams system, which attacks the ingot in the most effective way.

The draft-compressed ingots shown at Paris were extremely solid and free from cavities; and the reported increase in strength in the central parts through this compression was striking.

Tapering Tubes.—Tubes for trolley posts and other purposes are shown by the "Société Française pour la Fabrication des Tubes." They are said to be butt-welded by a secret process. The greatest length given is 46 ft. and the greatest diameter 9·75 in.

Microscope for Metallography.—Prof. H. Le Chatelier has perfected a microscope of great importance for the study of metals. Its chief advantages are: (1) that pieces of any size can be directly examined by it, as for instance, large finished steel objects, whereas if they are to be examined by a microscope of the common type, a small piece must be cut out of them for the purpose, a thing which is often undesirable or even impossible; and (2), thanks to his special mode of illuminating with monochromatic light, the expense of correcting the lenses to make them rectilinear and achromatic is greatly lessened, and moreover even a cheap lens, beside giving achromatic effects for direct visual examination, does the same for photomicrography. The microscope is made

* United States Patent No. 331,856, Dec. 8, 1885.

† I say "if properly applied," because if there is to be compression and therefore draft at the top of the ingot, the whole ingot must move bodily along through the mold; and if the draft at the top of the ingot is to equal that at the bottom, the walls of the mold must not only taper, but must have a curved taper.

by Pellin, 21 Rue de l'Odeon, Paris, and is described by Mr. Sauveur in his "Review of the Progress in Metallography during 1900," elsewhere in this volume.

UNFORGED ARMOR PLATE.—The Compagnie des Forges de Chatillon, Commentry et Neuves Maisons, Paris, exhibited an unforged steel cast armor plate, for which it claims as great ductility and resistance to perforation as are offered by forged or rolled plates. It is 8 in. thick, 58·5 in. wide, and about 7 ft. high. In a space 2 ft. square near its center it had been struck by 5 ninety-pound projectiles fired from a 6·25-in. gun, with a velocity of 1,165 ft. per second. All of the projectiles had fallen back from the plate, leaving clean depressions through none of which could I see daylight. I could detect neither cracks nor starring on the impact face.

TESTS AND ANALYSES OF METALLURGICAL PRODUCTS, ETC.—A very great number of such tests and analyses were shown at the Exposition or reported in the pamphlets supplied to the Jury and in other publications. I have collected and classified these and converted them into British units; and I now present them in the following tables. But, while thus bringing together this mass of very valuable scattered data which, unless thus presented was not likely to be conveniently accessible to our citizens, I have not reproduced the great mass of tests exhibited by Mr. Brinell, of Fagersta, because these are so important that they will certainly be made available in this country through the technical periodicals.

TABLE 1.—PHYSICAL PROPERTIES OF STEEL EXHIBITED OR REPRESENTED IN CONNECTION WITH THE PARIS EXHIBITION, 1900.

Maker, Country, or Authority.	Number.	Percentage. Carbon.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit.(d) Pounds per square in.	Elongation. %	Elongation. In	Contraction of Area. %
Soc. Anonyme de Commentry-Fourchambault, France.	1		Soft steel	66,300		28	...	
	2		Extra soft steel	53,300		36	...	
	3		Semi-soft steel	72,000		26	...	
	4	...	Half-hard steel	88,300		20	...	
Soc. Anonyme de Denain et d'Anzin, France.	5		Extra superior spring steel	271,700		6·3	...	
	6			241,800		7·9	...	
	7			274,500		5·5	...	
	8			270,200		6·5	...	
	9			253,200		5·5	...	
	10		Boiler plate steel	51,800		36	8″	66·7
	11			52,600		32·5	"	66·4
Soc. Anonyme des Aciéries et Forges de Trignac, France.	12		Rail steel	106,700		14	...	
	13			102,400		16	...	
	14			96,700		15	...	
	15			101,000		13	...	
	16			102,400		13	...	
	17			103,800		12	...	
	18		Hull plates	101,700		13·5	...	
	19			61,700		24·5	...	
	20			65,100		23·7	...	
	21		Strong ship steel	72,900		23·0	...	
	22		Very strong ship steel	86,500		17·5	...	
	23		Boiler plate steel	53,000		30·5	...	
	24			57,400		29·0	...	
	25			62,100		25·5	...	
	26			67,500		23·5	...	
Forges & Aciéries de la Marine et Chemins de Fer St. Chamond, France.	27		Mortar tube bored and hardened: Breech.	93,900	51,200	15	...	
	28		Mortar tube bored and hardened: Chase.	91,000	49,800	18	...	
	29		Trunnions for heavy ordnance, after hardening.	85,330	47,800	14·5	...	
	30			83,200	43,800	13·5	...	
	31		Locomotive tires	90,300		22·5	...	
	32			101,200		20·0	...	
	33			104,500		19·0	...	
	34		Tender tire	97,300		21·5	...	

TABLE 1.—*Continued.*

Maker, Country, or Authority.	Number.	Percentage. Carbon.	Treatment, Class, etc	Tenacity. Pounds per sq. in.	Elastic Limit. (*d*) Pounds per square in.	Elongation. %	Elongation. In.	Contraction of Area. %
Forges & Aciéries de la Marine et Chemins de Fer. St. Chamond, France.	35		Car tire	73,900		27·0	...	
	36			92,400		21·0	...	
	37		Street car tire	108,200		18·0	...	
	38		Boiler plate steel tested crosswise	58,400		26·5	8″	
	39			62,300		31·5	"	
	40			59,400		27·0	"	
	41		Same steel as Nos. 38, 39, 40, tested crosswise after being welded in the middle.	55,300		20·0	"	
	42			55,000		27·0	"	
	43			57,400		23·0	"	
	44		Extra soft firebox steel. Test pieces cut from same plate as Nos. 44 to 47 inclusive and welded in the middle. Lengthwise	56,000		30·5	...	
	45		 Crosswise	57,800		28·0	...	
	46		 Lengthwise	57,400		31·5	...	
	47		 Crosswise	54,000		32·0	...	
	48		Test pieces cut from same plate as Nos. 44 to 47 inclusive and welded in the middle. Lengthwise	51,200		22·5	...	
	49		Crosswise	52,300		25·6	...	
	50		Lengthwise	56,400		33·0	...	
	51		Crosswise	57,200		28·5	...	
	52		Common soft steel. Tested after welding	62,600	36,100	26·5	8″	
	53			57,200	34,800	24·0	"	
	54			56,900	37,200	29·0	4″	
	55			55,600	35,700	30·0	"	
	56			57,700	38,100	29·0	"	
	57			(*a*) 56,900	37,500	28·0	"	
	58	...		(*a*) 56,900	37,500	27·0	"	
	59		Extra soft steel. These pieces were taken from the deck plates of a cruiser.	53,300	31,800	40·0	"	
	60			52,500	30,800	39·0	"	
	61	...		(*a*) 53,300	30,800	37·5	"	
	62			(*a*) 51,500	30,800	36·0	"	
	63			(*a*) 52,500	30,800	36·0	"	
	64		Soft steel, Naval artillery quality	69,100	36,800	26·5	"	
	65			65,400	35,900	27·0	"	
	66		Medium steel, Artillery quality	87,300	44,500	21·0	"	
	67			88,300	44,500	22·0	"	
	68		Medium steel, Artillery quality	93,300	48,100	20·0	"	
	69			99,700	51,200	18·5	"	
	70		Gun steel (average of six tests)	99,500	64,000	18·0	"	
Aciéries de Micheville, Micheville Villerupt, France.	71		Extra soft steel. Unannealed	56,900		31·5	"	
	72		Annealed.	55,600		33·5	"	
	73		Soft steel No. 5. Unannealed	60,200		30·5	"	
	74		Annealed.	58,500		31	"	
	75		Soft steel No. 4. Unannealed	62,300		28·5	"	
	76		Annealed.	60,300		29·5	"	
	77		Soft steel No. 3. Unannealed	62,700		27·5	"	
	78		Annealed.	61,900		28	"	
	79		Soft steel No. 3, special. Unannealed	70,100		27	"	
	80		Annealed.	68,300		27·5	"	
	81		Half-hard steel No. 2. Unannealed	78,500		23·5	"	
	82		Annealed.	76,800		24·5	"	
Aciéries de Micheville, Micheville Villerupt, France.	83		Half-hard steel No. 2, bis. Unannealed	90,600		20·5	4″	
	84		Annealed.	87,500		23	"	
	85		Hard steel No. 1. Unannealed	106,100		15	"	
	86		Annealed.	103,100		18·5	"	
Aciéries de Longuy, Mont Saint Martin, France.	87		⅝ inch 16 mm. pin cut out cold from the head of an extra hard steel rail of basic Bessemer steel.	126,600		13	"	
Fabrique de Fer de Charleroi, Belgium.	88		Soft steel plate. Lengthwise	47,900	Before rupt're	29·5	"	
	89		Crosswise	48,200	"	32·5	"	
	90		Steel plate. Lengthwise	48,600	"	22	"	
	91		"	59,300	"	25	"	
Wm. Jessop & Sons, Ltd., Sheffield, England.	92		Propeller shaft	66,100		28	...	46·2
	93		Crank shaft	69,000		40	...	64
	94		Bloom	66,100		42	...	64
	95		Bloom	76,800		35	...	
	96		Locomotive wheel hub	61,100		36	...	
	97		Propeller shaft	62,600		28	...	52·39
Aktiebolaget Avesta Jernverk, Avesta, Sweden.	98	0·10	Nine steel test pieces rolled hot but not turned.	46,000	28,600	40·3	8″	78·4
	99	0·15		58,000	32,200	34·3	"	66·9
	100	0·20		64,700	35,400	29·0	"	61·0
	101	0·30		66,600	35,900	30·2	"	59·3
	102	0·40		76,700	34,800	23·2	"	53·3
	103	0·50		71,800	35,000	26·6	"	52·2
	104	0·60		84,300	38,800	16·5	"	40·6
	105	0·70		101,600	44,300	12·9	"	30·6
	106	0·80		105,700	35,800	12·8	"	30·6
	107	0·90		105,600	39,700	5·4	"	7·4
	108	0.90		107,600	41,900	8·0	"	14·0
	109	1·00		121,900	54,300	4·6	"	6·6
	110	1·00	Eight steel test pieces rolled hot and turned.	121,600	57,000	4·5	"	5·8
	111	1·10		118,500	53,300	4·2	"	5·0
	112	1·10		120,100	57,700	4·1	"	5·7
	113	1·20		109,900	56,600	2·9	"	2·9
	114	1·20		106,100	61,800	2·4	"	2·4

TABLE 1.—*Continued.*

Maker, Country, or Authority.	Number.	Percentage. Carbon.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit.(*d*) Pounds per square in.	Elongation. %	Elongation. In.	Contraction of Area. %
Aktiebolaget Söderfors Bruk, Söderfors, Sweden.	115	0·10	Rolled and hardened ("tempéré") (*b*).....	59,600	24,600	24·9	8″	59·1
	116	0·20		60,000	33,300	28·3	"	53·6
	117	0·40		78,300	37,400	20·9	"	48·3
	118	0·50		86,300	44,100	19·3	"	45·2
	119	0·60		101,400	43,600	12·2	"	34·1
	120	0·70		99,800	38,100	9·6	"	22·3
	121	0·80	Tool steel quality ("de ferronnerie"). Unhardened. Rolled.....	138,900	54,000	7·3	"	15·6
	122	0·80	Forged	124,400	58,200	12·5	"	23·3
	123	0·90	Rolled.	150,000	50,600	8·3	"	15·5
	124	0·90		131,600	79,500	7·0	"	19·1
	125	1·05		104,700	54,000	6·5	"	12·1
	126	1·10	Forged.....	122,800	77,800	3·8	"	6·2
	127	1·20		105,400	58,700	8·2	"	2·0
	128	1·40		106,500	57,400	4·1	"	5·8
	129	0·80	Rolled..	123,300	45,600	8·6	"	19·3
	130	0·80	Forged.....	113,000	55,500	11·4	"	27·3
	131	0·90	Rolled	142,200	51,300	6·9	"	10·2
	132	0·90	Tool steel quality ("d'outils"), not hardened.	103,900	75,200	7·6	"	30·5
	133	1·00		121,700	70,100	7·2	"	9·3
	134	1·10	Forged.....	117,900	67,700	5·8	"	1·3
	135	1·20		125,200	75,800	7·0	"	8·8
	136	1·50		98,100	53,700	9·3	"	22·5
Aktiebolaget Iggesunds Bruk, Iggesund, Sweden.	137	0·50		84,300	32,300	14·4	"	33·2
	138	0·60		100,500	42,400	11·8	"	19·6
	139	0·70		114,600	41,400	9·8	"	18·0
	140	0·80	Results obtained from two tests on each of 8 steel test pieces.	135,100	50,600	8·9	"	10·3
	141	0·90		141,200	52,900	6·8	"	8·5
	142	1·00		147,300	72,200	2·7	"	4·0
	143	1·10		142,900	55,000	6·5	"	9·9
	144	1·20		131,400	55,100	13·5	"	1·6
	145	0·50		94,000	42,900	18·5	"	34·7
	146	0·60		111,500	40,600	11·0	"	13·0
	147	0·70		109,700	40,900	14·5	"	25·8
	148	0·80		135,600	52,000	9·60	"	11·1
	149	0·90	Eight round specimens of steel.....	145,400	58,700	8·30	"	12·2
	150	1·00		150,200	74,600	3·00	"	5·4
	151	1·10		155,300	61,300	6·7	"	10·7
	152	1·20		128,900	63,300	2·0	"	1·9
Aktiebolaget Österby Bruk, Dannemora, Sweden.	153	0·60		108,400	72,400	15·3	6″	36·0
	154	"	"Tempéré".	(*b*)120,700	52,000	10·3	"	14·6
	155	0·80		134,800	72,400	9·0	"	15·2
	156	"	"Tempéré".	(*b*)120,700	62,300	12·3	"	29·7
	157	1·00		146,600	96,600	9·0	"	15·3
	158	"	Crucible steel. "Tempéré".	(*b*)135,100	77,200	9·7	"	17·9
	159	1·20	"Dannemora."	143,300	102,100	4·7	"	8·3
	160	"	"Tempéré".	(*b*)104,100	68,800	13·7	"	28·1
	161	1·40		154,600	88,000	5·1	"	6·6
	162	"	"Tempéré".	(*b*)104,800	65,000	14·6	"	24·2
	163	1·60		139,700	96,600	4·3	"	
	164	"	"Tempéré".	(*b*)112,400	72,000	11·6	"	15·9
Boehler Bros., Kapfenberg, Austria.	165			118,000	91,000	19	...	46
	166			122,300	99,600	18	..	39
	167			118,000	88,200	20	...	48
	168			116,600	88,200	20	...	49
	169			113,800	79,600	20	...	50
	170			122,300	96,700	18	...	44
	171			122,300	85,300	17	...	46
	172			118,000	82,500	19	...	50
	173		Gun barrels of crucible steel. Special quality.	112,400	79,600	20	...	51
	174			116,600	82,500	18	...	45
	175			119,500	88,200	20	...	50
	176			128,000	102,400	18	...	40
	177		(The wording suggests that these tests were applied to the gun barrels themselves, rather than to test pieces cut from them.)	119,500	85,300	19	...	50
	178			122,300	88,200	18	...	48
	179			120,900	85,300	17	...	46
	180			119,500	85,300	18	...	50
	181			118,000	82,500	20	...	50
	182			119,500	85,300	18	...	48
	183			120,900	88,200	18	...	50
	184			119,500	82,500	19	...	52
	185			119,500	85,300	18	...	50
	186			122,300	88,200	17	...	46
	187			120,900	85,300	19	...	50
	188			120,900	88,200	18	...	48
Soc. Anonyme des Laminoirs de tubes et de fer de Sosnowice, Russia.	189		Boiler plate steel (*c*). P=0·03. S=0·01. Average of 19 tests, lengthwise	50,400		31·6	...	
	190	0·09	Maximum, "	56,500		35·0	...	
	191	"	Minimum, "	44,200		26·0	...	
	192	"	Average of 19 tests, crosswise.	51,400		31·8	...	
	193	"	Maximum, "	58,400		35·0	...	
	194	"	Minimum, "	46,900		28·5	..	
	195	"	P=0·02. S=0·01. Average of 16 tests, lengthwise	52,200		30·8	...	
	196	"	Maximum, "	57,600		36·5	...	
	197	"	Minimum, "	47,600		26·5	...	
	198	"	Average of 16 tests, crosswise.	52,200		31·0	...	
	199	"	Maximum, "	57,900		35·0	...	
	200	"	Minimum, "	48,300		27·0	...	

TABLE 1.—*Concluded.*

Maker, Country, or Authority.	Number.	Percentage. Carbon.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit. (*a*) Pounds per square in.	Elongation. %	Elongation. In.	Contraction of Area. %
Soc. Anonyme des Forges et Aciéries de Huta Bankowa, Russia.	201		Miscellaneous steel	47,600		35·0	8″	
	202			53,200		33·7	"	
	203			56,900		30·3	"	
	204			63,400		28·4	"	
	205			68,100		27·5	"	
	206			74,400		25·3	"	
	207			80,200		24·8	"	
	208			87,200		22·7	"	
	209			97,000		21·5	"	
	210			106,500		19·2	"	
	211			112,900		17·5	"	
	212			119,600		15·1	"	
	213			128,400		12·5	"	
			STEEL MANUFACTURED OBJECTS.					
Aktiebolaget Iggesunds Bruk, Iggesund, Sweden.	214		Eight weldless soft steel tubes, rolled hot, unfinished.	59,900	28,600	30·8	8″	
	215			59,600	28,800	30·8	"	
	216			67,800	35,100	29·0	"	
	217			67,400	35,100	30·	"	
	218			69,100	33,100	28·6	"	
	219			68,700	33,100	26·8	"	
	220			78,100	34,800	27·7	"	
	221			78,300	33,700	26·5	"	
Aktiebolaget Fagersta Bruk, Fagersta, Sweden.	222		Two soft steel tubes	52,500	30,300	32·9	7″	
	223			46,600	27,900	35·7	"	

(*a*) Test suspended before rupture to determine contraction.

(*b*) These specimens are called in the originals "tempéré," which literally means "tempered." If they are of normal carbon steel, their properties do not indicate that they have been simply hardened, for the elongation of the "tempéré" specimen is generally much greater than that of the corresponding apparently unhardened specimen. It is not clear in what sense "tempéré" is here used.

(*c*) Nos. 189 to 200. Both in the case of the set of 19 tests and in that of 16 tests, the maximum tenacity lengthwise and crosswise represent the same plate. This is not true, however, of the minimum tenacity. Naturally, the maximum tenacity and the maximum elongation, though here given in the same line, do not represent the same specimen.

(*d*) The elastic limit of the Austrian specimens (Nos. 165 to 188, inclusive), and of all the Swedish specimens (Nos. 98 to 164, inclusive, and 214 to 221, inclusive), is the "proportionality limit." The elastic limit of the Fagersta (Swedish) specimens (Nos. 222 and 223) is the "apparent" elastic limit. In few, if any, of the other cases is it stated how the elastic limit is determined.

TABLE 2.—PHYSICAL PROPERTIES OF SPECIAL STEELS. (*a*)

Maker, Country, or Authority.	Number.	Percentage. Carbon.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit Pounds per square in.	Elongation. %	Elongation. In	Contraction of Area. %
Aciéries et Forges de Firminy, France.	1		Armor plate steel	113,800	82,500	18		62
	2		Gun steel	99,500	65,400	19		53
	3		Steel for connecting rods	97,400	66,300	63		52
Forges et Aciéries de la Marine et Chemins de Fer, St. Chamond, France.	4		St. Chamond special steel. Marine engine shaft	92,300	62,000	21·0	4″	
	5			96,800	66,400	26·0	"	
	6		St. Chamond special steel. Test pieces from cemented steel armor plate for armored vessel.	104,200	71,700	18·0	"	
	7			104,800	72,400	18·5	"	
	8		St. Chamond special steel. Locomotive axle	90,000	58,600	21·5	"	
	9			96,400	64,300	18·5	"	
	10		St. Chamond special steel. Ordnance steel	110,500	73,200	18·0	"	
	11			99,700	67,300	19·0	"	
	12			100,800	68,300	19·5	"	
	13			100,800	67,300	21·0	"	
	14			100,800	68,300	18·5	"	
	15			99,700	64,000	21·0	"	
	16			97,800	63,500	22·5	"	
	17		St. Chamond special steel. Small shaft for automobile torpedo.	106,700	82,500	19·0	..	
	18		St. Chamond special steel. Average of eight tests	128,000	92,400	14·0		
	19		Bar of rudder sliding carriage. Special steel hardened.	119,500	75,400	12		
Aktiebolaget Österby Bruk, Dannemora, Sweden.	20	1·00	Special Dannemora	164,400	*b* 109,400	7·1	6″	16·7
	21	1·40	Extra special Dannemora	179,300	*b* 88,000	6·1	"	14·6
	22	1·60		173,700	*b* 88,300	1·9	"	4·3

(*a*) The specimens represented in this table were called "Special Steels." Number 3 resembles nickel steel in its great elongation.

(*b*) The elastic limit is the "Proportionality limit." In few, if any, of the other cases is it stated how the elastic limit is determined.

TABLE 3.—PHYSICAL PROPERTIES OF ALLOY STEELS.

Maker, Country, or Authority.	Number.	Percentage of Nickel.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit. (a) Pounds per square in.	Elongation. %	Elongation. In	Contraction of Area. %
			NICKEL STEEL.					
	1	2	Lengthwise — Unhardened	96,000	60,800	25		53·2
	2	"	Lengthwise — Hardened	139,800	124,600	14·5		53·7
	3	"	Crosswise — Unhardened	95,100	57,100	23·5		42·1
	4	"	Crosswise — Hardened	119,900	98,800	16		57·4
	5	5	Lengthwise — Unhardened	98,000	68,500	20·5		49·6
	6	"	Lengthwise — Hardened	133,100	123,600	16·5		57·4
	7	"	Crosswise — Unhardened	93,300	61,800	18·5		42·1
	8	"	Crosswise — Hardened	120,700	109,300	15		53·7
	9	6		77,400	58,400	29		70·5
	10	8		89,300	74,500	25		70·5
	11	10		108,800	87,000	19·5		66·5
	12	12		117,000	98,000	19		64·0
Soc. Anonyme de Commentry Fourchambault, France.	13	"	Annealed at 400°C.	159,000	117,900	15·5		59·9
	14	"	Hardened at 400°C.	173,200	147,400	15·5		53·6
	15	"	Crosswise, annealed at 600°C.	110,900	97,700	15·5		63·0
	16	14		132,300	98,100	15	...	59·0
	17	16		183,500	104,500	12·2		50·0
	18	"	Unhardened	124,700	66,500	60		66·4
	19	"	Hardened	113,100	49,500	67·5		63·8
	20	20	Unhardened	194,800	121,700	13·5	...	52·0
	21	"	Hardened	214,500	129,400	17		42·4
	22	25	Unhardened	133,700	70,400	60·5		47·5
	23	"	Hardened	115,200	46,600	88·5		48·1
	24	36	Lengthwise, unhardened	134,400	85,000	27	...	47·5
	25	"	Hardened	129,800	77,900	31		43·3
	26	44	Lengthwise, unhardened	100,000	59,000	40		62·9
Forges et Aciéries de la Marine et Chemins de Fer, St. Chamond, France.	27	20 to 25	Cylinder	103,800	49,800	64	4in.	
	28	20	Test pieces taken from piece of ordnance.	104,500	50,300	63·5	"	
	29	to		103,500	50,300	65·0	"	
	30	25		104,500	52,200	64·0	"	
	31	5		123,100	97,600	16·5	"	
	32	"		143,200	105,400	12·5	"	
	33	6		145,400	101,700	12·5	"	
	34	6		164,400	111,600	7·5	"	
	35	10		234,300	127,100	9	"	
	36	"		220,400	113,800	9·5	"	
Soc. Anonyme de Denain et d'Anzin, France.	37	24		107,500	44,100	110	"	
	38	"		108,900	45,500	108	"	
	39	26		109,600	41,100	105	"	
	40	"		110,900	45,500	103	"	
	41	27		108,900	58,100	90	"	
	42	"		105,900	37,400	99	"	
	43	30		108,100	39,800	97	"	
	44	"	Hardened	105,200	39,200	99	"	
Aciéries et Forges de Firminy, France.	45	22 to 25		112,200	43,200	62	...	
	46			114,000	59,800	69·5		
Aciéries d'Unieux (Jacob Holtzer & Co.), France.	47	25	Apparently a casting	82,500	33,100	51·5	4in.	
Soc. Le Ferro. Nickel, Lizy sur Ourcq, France.	48	25	Test pieces rolled or forged, annealed at cherry red heat (about 900°C), then cooled slowly; protected from the air. — Extra soft	88,200	31,300	45	"	
	49	"		to 92,400	to 35,600	—50	"	
	50	"	Soft	96,700	39,800	45	"	
	51	"		to 102,400	to 45,500	—50	"	
	52	"	Strong	102,400	46,900	40	"	
	53	"	Soft (doux resistant)	to 106,700	to 54,000	—45	"	
	54	"	Half hard	106,700	56,900	35	"	
	55	"		to 113,800	to 64,000	—40	"	
Compᵉ des Forges de Chatillon, Commentry et Neuves Maisons, France.	56	25	⅛ inch (3 mm) plates. — 6 Lengthwise, unhardened	124,800	76,500	40	"	
	57	"	8 " hardened	120,100	61,400	45·5	"	
	58	"	3 Crosswise, unhardened	127,600	75,400	38·5	"	
	59	"	5 " hardened	121,200	60,700	45	"	
	60	"	5/64 inch (2 mm) plates. — 2 Lengthwise, unhardened	128,400	72,800	38	"	
	61	"	6 " hardened	120,500	56,300	37	"	
	62	"	5 Crosswise, unhardened	127,200	71,700	33·5	"	
	63	"	8 " hardened	118,700	56,200	36	"	
	64	"	1/16 inch (1·5 mm) plates. — 3 Lengthwise, unhardened	128,600	78,600	30	"	
	65	"	6 " hardened	113,000	48,200	41·5	"	
	66	"	5 Crosswise, unhardened	119,000	77,800	28	"	
	67	"	8 " hardened	133,900	46,900	36·5	"	

TABLE 3.—*Concluded.*

Maker, Country, or Authority.	Number.	Percentage of Nickel.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit. (a) Pounds per square in.	Elongation. %	Elongation. In.	Contraction of Area. %
Usines, Skoda, Pilsen, Austria.	68			99,500	56,900	14		
Aktiebolaget Österby Bruk, Dannemora, Sweden.	69		Carbon=1·00% Dannemora nickel.....	156,700	75,900	4·2	6in.	5·9
	70		" =1·20% Dannemora nickel.....	173,400	83,300	6·1	"	4·5
	71		" =1·00% Dannemora nickel, steel hardened (tempéré).	104,700	55,900	14·7	"	29·9
	72			117,900	72,100	13·7	"	21·7
		% Cr	CHROME STEEL.					
Forges et Aciéries de la Marine, etc., St. Chamond, France.	73		Chrome steel for projectiles.....	117,200	69,100	20	4in.	
	74			110,800	66,400	21·5	"	
	75			114,000	68,300	19·0	"	
Aciéries d'Unieux (Jacob Holtzer & Co.), France.	76	5	Carbon=0·4 per cent. Quenching gives the steel a very great hardness. Annealed.....	71,100	39,800	24	"	
	77	"	Hardened & annealed..	123,600	109,200	12	"	
	78	10	Annealed.....	94,000	51,200	21·5	"	
	79	"	Hardened & annealed..	121,600	95,000	12	"	
	80	15	Annealed.....	101,500	56,900	18·5	"	
	81	"	Hardened & annealed..	130,100	109,200	11·5	"	
	82	20	Quenching acts but much less energetically Annealed.....	80,700	47,500	21·5	"	
	83	"	Hardened & annealed..	90,100	61,700	19·5	"	
	84	25	Quenching produces no effect. Annealed.....	94,400	65,500	18	"	
	85	"	Hardened & annealed..	90,600	61,700	20	"	
	86	30	Annealed.....	93,000	68,500	19·0	"	
	87	"	Hardened & annealed..	87,300	64,500	19	"	
	88	35	The test pieces behave badly and give no elongation nor contraction of area.					
	89	1·6		127,300	123,300	10	4in.	
	90	"		136,500	130,800	10·5	"	
	91	2·16		111,900	103,200	13	"	
	92	"		151,700	135,700	7·5	"	
	93	3·47		154,500	144,200	9	"	
Soc. Anonyme de Denain et d'Anzin, France.	94	"		163,900	151,600	11	"	
	95	4		158,200	100,400	8	"	
	96	"		176,300	170,700	9·5	"	
	97	6·67		116,000	81,800	11	"	
	98	"		146,200	109,900	8	"	
	99	10		64,600	52,200	25	"	
	100	"		127,300	108,100	12	"	
	101	12		147,000	111,800	8	"	
		% Mn.	MANGANESE STEEL.					
	102	2·5		105,200	83,300	15	4in.	
	103	"		101,500	79,300	18·5	"	
	104	"		111,700	89,000	14	"	
	105	"		109,500	91,700	14	"	
	106	3		152,900	140,800	10	"	
	107	"		143,400	108,500	11·5	"	
Soc. Anonyme de Denain et d'Anzin, France.	108	15		99,500	53,000	11	"	
	109	16		131,700	61,900	49	"	
	110	"		118,700	57,800	30	"	
	111	19		117,600	53,000	21	"	
	112	29		138,500	61,700	54	"	
	113	"		138,500	60,600	49	"	
	114	30		133,400	73,100	55	"	
	115	"		121,600	67,400	33	"	
		% Al	ALUMINUM STEEL.					
Soc. Anonyme de Denain et d'Anzin, France.	116	2		125,400	73,100	9	4in.	
	117	"		124,400	69,100	13	"	
	118	"		62,400	37,000	25	"	
		% Si.	SILICON STEEL.					
	119	2·48		123,100	87,200	14·5	4in.	
	120	"		133,000	99,100	11	"	
Soc. Anonyme de Denain et d'Anzin, France.	121	"		273,000	241,300	6	"	
	122	"	Hardened.....	271,600		3	"	
	123	3		121,400	96,700	13	"	
	124	"		134,500	113,800	6	"	
	125	4		127,300	127,300	0·5	"	
		% C.	TUNGSTEN STEEL.					
Aktiebolaget Österby Bruk, Dannemora, Sweden.	126	1·00		156,700	111,100	5·0	6in.	7·8
	127	1·10	Dora Wolfram.....	151,900	109,100	5·8	"	6·8
	128	1·20		159,600	116,900	1·2	"	2·8

(a) The elastic limit of the Österby Bruk (Swedish) specimens of Nickel Steel (Nos. 69 to 72. inclusive) and Tungsten Steel (Nos. 126, 127 and 128), is the "Proportionality limit." In few, if any, of the other cases is it stated how the elastic limit is obtained.

TABLE 4.—PHYSICAL PROPERTIES OF STEEL CASTINGS.

Maker and Country.	Number.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit. Pounds per square in.	Elongation. %	Elongation. In	Contraction of Area. %
Compie des Forges de Châtillon, Commentry & Neuves Maisons, France.	1	Steel castings. Alexandre III. Bridge, Paris. Carbon=0·45 %; Silicon=0·35 %; Manganese=0·50 %.	78,200	40,500	16·5		
Aciéries et Forges de Firminy, France.	2		74,200	43,600	19		
Aciéries d'Unieux (Jacob Holtzer & Co.), France.	3	Crucible steel castings. (The wording, while vague, leaves very little doubt that these are castings.)	59,700	45,500	29	4in.	
	4		67,400	48,200	27	"	
	5		76,100	53,200	20	"	
	6		82,500	59,900	17·5	"	
	7		88,600	58,600	14	"	
	8		95,300	73,900	10·5	"	
Soc. Anonyme des Usines Skoda, Pilsen, Austria.	9		78,900		21	8in.	
	10		60,800		26	"	
	11		69,200		22	"	
	12		71,200		21	"	
	13		62,000		29	"	
	14		60,700		26	"	
	15		62,600		24	"	
	16		63,500		27	"	
	17		62,400		28	"	
	18		73,600		20	"	
	19	Propeller post. Upper part.	76,800		14·5	"	31
	20	Propeller post. Lower part.	64,800		21	"	30
	21		66,300		24	"	40
	22		75,700		17	"	46
	23	Propeller post. Upper part.	65,400		21·5	"	43
	24	Propeller post. Lower part.	60,300		21	"	37
	25	Shaft bearing.	66,300		23	"	36
	26	Shaft bearing.	69,400		22	"	31
	27		65,400		22·5	"	43
	28	Stem	67,500		22·5		40
	29	Shaft	66,800		21		20
	30	Shaft	67,700		21·5		29
	31	Shaft couplings.....	68,800		21		32
	32	Anchors.....	70,300		20	8in.	32·3
	33	Anchors.....	65,700		27	"	47·5
	34	Anchors.....	64,600		22	"	29·0
	35	Foundation plates.....	68,300		23	"	
	36	Foundation plates.....	69,700		21	"	
	37	Foundation plates.....	69,700		21	"	
	38		66,800		22	"	
	39	Links (Coulisse).....	68,300		14	"	
	40	Links (Coulisse).....	69,700		19·5	"	
	41	Links (Coulisse).....	68,300		22	"	
	42	Piston.....	68,300		19	"	
	43	Piston.....	69,700		20·5	"	
	44	Piston.....	69,700		19·5	"	
	45		66,800		19	"	

TABLE 5.—PHYSICAL PROPERTIES OF WROUGHT IRON AND CAST IRON.

Maker and Country.	Number.	Treatment, Class, etc.	Tenacity. Pounds per sq. in.	Elastic Limit. Pounds per square in.	Elongation. %	Elongation. In	Contraction of Area. %
Fabrique de Fer de Charleroi, Belgium.	1	No. 5 wrought iron plates.. Lengthwise..	49,000		19·5	8in.	
	2	No. 5 wrought iron plates.. Crosswise....	46,200		12·5	"	
	3	No. 4 wrought iron plates.. Lengthwise..	48,300		15·5	"	
	4	No. 4 wrought iron plates.. Crosswise....	42,800		8	"	
	5	No. 3 wrought iron plate.....Lengthwise..	47,500		8·5	"	
	6	Wide No. 3 wrought iron plate. Lengthwise	51,500		18	"	
Soc. Anonyme de Denain et d'Anzin, France.	7	Special cast iron (can be forged).....	131,100		2		

TABLE 6.—CHEMICAL COMPOSITION OF CAST IRON, WROUGHT IRON AND STEEL.

Maker, Country, or Authority.	Number.	Treatment, Class, etc.	Composition. Gr.	C. C.	Total C.	Si.	Mn.	P.	S.	Fe.	Total
		NORMAL CAST IRON.									
	1	Ordinary quality. Pig for steel making.				1·20	1·50	0·60	0·03		
	2	Ordinary quality. Pig for steel making.				0·90	1·20	0·60	0·06		
	3	Ordinary quality. Pig for puddling.				0·80	1·00	0·60	0·09		
	4	Ordinary quality. Pig for puddling.				0·60	0·80	0·60	0·15		
	5	Medium quality. Pig for puddling.				1·20	1·60	0·16	0·06		
	6	Medium quality. Pig for puddling.				1·00	1·40	0·16	0·08		
	7	Medium quality. Basic open-hearth pig.				0·80	1·20	0·16	0·10		
	8	Medium quality. Basic open-hearth pig.				0·80	2·50	0·16	0·04		
	9	Medium quality. Basic open-hearth pig.				0·70	2·50	0·16	0·05		
	10	Medium quality. Basic open-hearth pig.				0·60	2·50	0·16	0·06		
	11	Dephosphorized pig				0·05	1·00	0·020	0·150		
	12	Dephosphorized & desulphurized. Mottled gray pig for steel making.				0·80	1·00	0·012	0·002		
	13	Dephosphorized & desulphurized. Banded pig for steel making.				0·70	1·00	0·012	0·002		
Aciéries et Forges de Firminy, France.	14	Dephosphorized & desulphurized. White pig for puddling				0·60	0·80	0·015	0·005		
	15	Desulphurized mottled gray pig for refinery.				1·20	2·20	0·150	0·003		
	16	Low phosphorus pig for steel making.				1·50	2·00	0·060	0·015		
	17	Low phosphorus pig for steel making.				1·30	1·80	0·060	0·025		
	18	Low phosphorus pig for steel making.				1·00	1·80	0·060	0·040		
	19	Low phosphorus pig for puddling.				1·10	1·80	0·070	0·040		
	20	Low phosphorus pig for puddling.				0·90	1·60	0·070	0·050		
	21	Low phosphorus pig for puddling.				0·80	1·50	0·070	0·060		
	22	Low phosphorus pig for puddling.				0·70	1·40	0·070	0·080		
	23	Low phosphorus pig for puddling. Crystalline ..				0·60	1·40	0·070	0·060		
	24	Low phosphorus pig for puddling. Dull				0·50	1·20	0·070	0·100		
	25	Low phosphorus pig for rolet process (with blow-holes.				0·40	1·00	0·070	0·150		
	26	Extra strong foundry pig...				1·60	1·50	0·15			
	27	Extra strong foundry pig...				1·25	1·50	0·15			
	28	Extra strong foundry pig...				1·00	1·30	0·15			
	29	Extra strong foundry pig...				0·85	1·00	0·15			
Société Metallurgique de Goruy, France.	30	Forge pig			2·750	0·495	0·118	1·820	0·500		
	31	Forge pig			3·200	0·350	2·000	1·900	0·020		
	32	Forge pig			3·600	1·250	1·500	0·088	0·021		
Forges et Aciéries de la Marine et Chemins de Fer St. Chamond, France.	33	Foundry pig, No. 1			4·10	2·50	1·40	0·070	0·016		
	34	Foundry pig, No. 4			3·40	1·40	1·00	0·070	0·070		
	35	Desulphurized pig			4·60	0·30	0·40	0·070	tra'e		
Aciéries d'Isbergues, France.	36	Foundry pig. Gray			4·25	3.50	1·90	0·05	0·01	90·00	99·71
	37	Foundry pig. Gray			4·00	3·25	1·85	0·05	0·02	90·50	99·67
	38	Foundry pig. Gray			3·75	3·00	1·80	0·05	0·03	91·00	99·63
	39	Foundry pig. Gray			3·50	2·50	1·75	0·05	0·04	92·00	99·84
	40	Foundry pig. Mottled gray			3·25	2·00	1·65	0·05	0·05	92·90	99·90
	41	Forge pig. Mottled white.			3·00	1·50	1·50	0·05	0·06	93·80	99·91
	42	Forge pig. White			3·00	0·90	1·25	0·05	0·09	95·00	100·29
	43	Gray pig	3·61	0·38	3·99	1·47	1·78	0·018 to 0·021	0·009		
Usines de Fagersta, Fagersta, Sweden.	44	Lighter gray pig	3·35	0·46	3·81	1·38	1·67	"	0·012		
	45	Lighter gray pig	3·06	0·69	3·75	0·95	1·35	"	0·010		
	46	Light gray pig	2·25	1·44	3·69	0·80	1·15	"	0·012		
	47	("Grise blanche")	0·16	3·42	3·58	0·75	1·15	"	0·010		
	48	("Grise blanche")	0·05	3·67	3·72	0·59	1·05	"	0·010		
	49	White pig	0·00	3·70	3·70	0·30	0·65	"	0·011		
Aktiebolaget Iggesunds Bruk, Iggesund, Sweden	50	Cold blast pig iron for export				0·20 to 0·60	0·60 to 0·80	0·014 to 0·019	0·005 to 0·010		
Usines Kyschtym, Russia.	51	Foundry pig for art castings	2·030	1·460	3·490	0·514	0·180	0·350	0·016	95·450	100·00
	52	Foundry pig for art castings	2·530	1·644	4·174	0 562	0·425	0·642	0·020	94·177	100·00
Hughsovka, Russia.	53	Gray pig	3·60	0·20	3·80	2·80	0·85	0·28	0 05	93·22	
	54	Bessemer pig	2·950	0·150	3·100	1·900	0·980	0·065	0·030	93·925	
	55	Pig No. 2	2·900	0·330	3·230	2·350	0·850	0·280	0·090	93·200	
	56	Bessemer pig before going to mixer.	3·100	0·150	3·250	2·100	1·200	0·065	0·090	93·225	
	57	Bessemer pig after coming from mixer.	2·950	0·250	3·200	1·900	0·280	0·065	0·030	93·925	
		ALLOY CAST IRONS.	Cr.	W.							
Aciéries de la Marine des Chemins de Fer, St. Chamond, France.	58	Spiegeleisen			6·00	0·60	40·00	0·120	0·010		
	59	Ferromanganese			7·30	0·50	80·00	0·200	0·010		
	60	Ferrochrome	62·00		8·60	0·50	0·20	0·050	tra'e		
	61	Ferrochrome	70·00		9·05	0·45	0·15	0·050	tra'e		
	62	Ferrotungsten		80·00	3·60	2·40	0·50	0·050	tra'e		
Aciéries d'Isbergues, France.	63	Ferrosilicon			3·00	7·50	1·75	0·05	0·01	87·50	99·81
	64	Spiegeleisen			4·50	0·60	11·00	0·05	0·01	83·75	99·91
	65	Spiegeleisen			5·00	0·70	20·00	0·18		73·99	
Hughsovka, Russia.	66	Ferromanganese			6·00	0·90	50·00	0·20		42·85	

TABLE 6.—*Concluded.*

Maker, Country, or Authority.	Number.	Treatment, Class, etc.	Composition.								
			Gr.	C. C.	Total C.	Si.	Mn.	P.	S.	Fe.	Total
		WROUGHT IRON.									
Aciéries et Forges de Firminy, France.	67	Rollet iron, Swedish quality			0·05 to 0·25			0·015	0·003		
	68	Superior wrought iron.....			0·05 to 0·25			0·025	0·006		
	69	Fine wrought iron ("Fers fins.")			0·05 to 0·25			0·040	0·006		
Aktiebolaget Iggesunds Bruk, Iggesund, Sweden	70	Dannemora walloon iron....				0·02 to 0·03	0·08 to 0·10	0·004 to 0·006	tra'e to 0·005		
	71	Dannemora charcoal hearth bar iron.				0·02 to 0·03	0·10 to 0·12	0·006 to 0·010	0·001 to 0·006		
	72					0·02 to 0·03	0·10 to 0·12	0·010 to 0·012	0·001 to 0·006		
		PUDDLED STEEL.									
Aciéries et Forges de Firminy, France.	73				0·60 to 1·10			0·025	0·008		
		MISCELLANEOUS STEEL.									
Aciéries d'Isbergues, France.	74	Soft steel.....			0·10		0·40	0·02	0·04		
Aktiebolaget Iggesunds Bruk, Iggesund, Sweden	75	Bessemer steel.....				0·025 to 0·035	0·20 to 0·30	0·029 to 0·024	tra'e to 0·005		
Usine Noworossisski, Russia.	76	Rail steel			0·40 to 0·45	0·08	1·10	0·065	0·02		

Alloys of Iron.

By Henry Souther.

It is probably not realized by most people that the iron we use and speak of generally is not pure iron, but in reality a very complicated alloy of iron with many other elements. Iron (ferrum) used alone, that is, not combined with other elements, would be of little use for structural purposes. The demands made upon structural materials are too great and the resistance offered by pure iron too small to meet requirements of modern practice. Pure iron is not harder than copper, nor is it stronger. In addition to this pure iron is most expensive to obtain, because it can be separated from some of the elements associated with it only at great expense, or be obtained from the best selected and very expensive ores.

The term iron is used promiscuously when one refers to meteoric iron, to cast iron, to malleable iron, to puddled and forged iron and to the specimen of pure iron found in the mineral cabinet.

Some of these materials do not resemble each other in appearance, structure or physical characteristics in the slightest degree, and yet they are almost entirely made up of iron (ferrum). The marked changes brought about by eliminating

or adding only a fraction of a per cent. of an element have only been appreciated and understood for a very short period. Some changes occur now as a consequence of adding increased amounts of an element to iron that seem absolutely incomprehensible with our present knowledge. Manganese steel is probably the most startling example of this kind.

The term steel is used by every one and understood by a very few. Steel can be separated from iron by description with very great difficulty. Some irons resemble soft steel so closely that to distinguish one from the other would be impossible, were it not for the fact that iron has a very distinct fibrous structure, resulting from the process of manufacturing it, which consists of drawing out by rolls or hammer a pasty mass of irregular shaped plastic bits (separated by cinder or slag) into long fibers. Steel, on the other hand, has no such structure, because when made it is brought into a perfect liquid condition and cast into some form. Gases and impurities have time to rise to the surface before the mass solidifies, if they have not done so during the melting process.

In a cast condition steel is a homogeneous mass of crystals, and when hammered or forged it remains a homogeneous body with no structure of any kind visible except under the high power microscope. It is then seen that the crystals or particles have been elongated or otherwise distorted by physical work done on them.

Steel is an alloy of iron just as the other kinds of iron that have been mentioned are, but the name steel now covers a large number of widely varying alloys, each having its own characteristics and suitability for some particular class of work. It is only during the last 20 or 30 years that the influence of each element has been at all understood, and now from time to time a fresh one is brought into prominence that has some new and marked effect on iron, one perhaps that amounts to something commercially, or perhaps interesting only from a scientific standpoint.

The following elements are nearly always associated with iron: Carbon, phosphorus, manganese, sulphur, silicon and copper. Two other elements, sulphur and copper, when they are associated with it cannot be entirely separated from it commercially. Phosphorus can only be removed by a process evolved almost exclusively to do so, that is, the basic process of steel making. The preceding group of elements might be classed as those that alloy naturally with iron. The following group, including some of the foregoing, have been introduced for various purposes and with widely differing results. BENEFICIAL: *Commercial.* (In finished alloy.)—Nickel, manganese, chromium, tungsten and molybdenum. (During manufacture.)—Aluminum and silicon. *Experimental.*—Boron and cobalt. INJURIOUS: Copper, arsenic, phosphorus, surphur and titanium. (?)

Thirteen elements were experimented with in a very systematic manner by Prof. J. O. Arnold.* The compositions are given in the following table. The resulting alloys are not all commercial or even useful in a small way, but illustrate the varying effect of about 1·50% of the element added. This table and the curves in the accompanying illustration, show at a glance the characteristic effects of the elements experimented with, excepting the wide variations

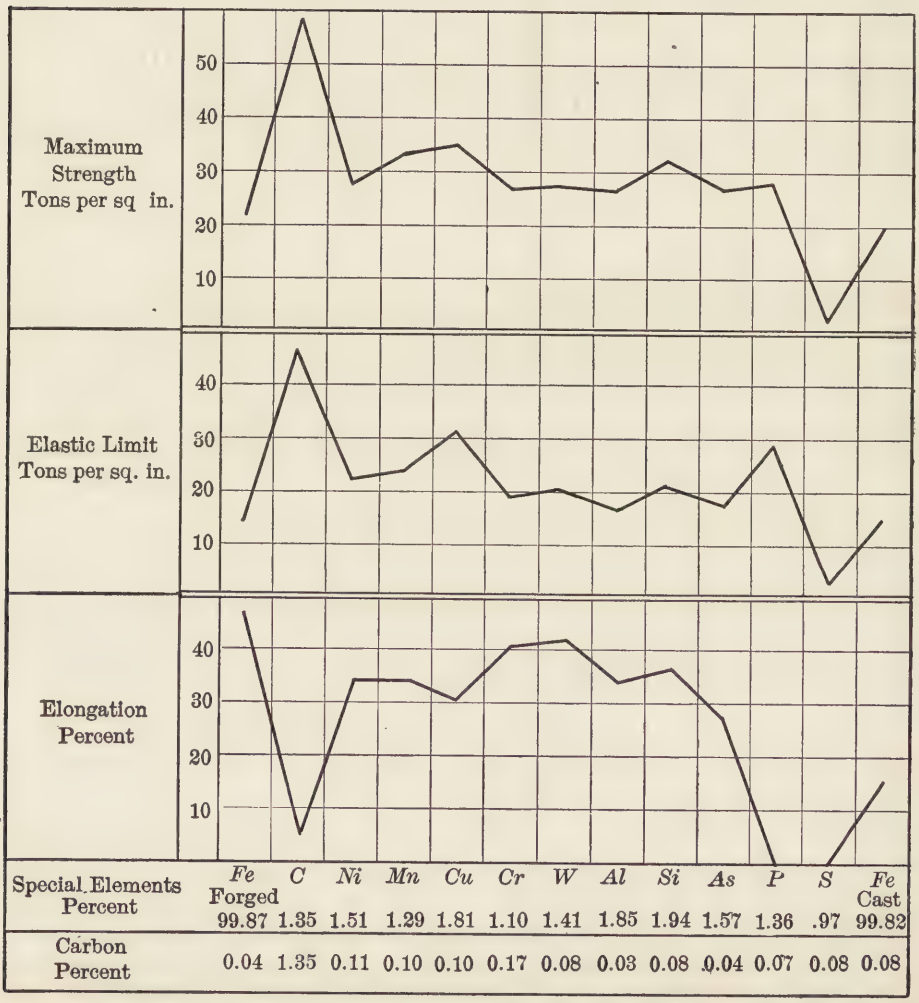
* *Journal of the Iron and Steel Institute*, 1894, No. I., p. 107, *et seq.*

CHEMICAL COMPOSITIONS AND SPECIFIC GRAVITIES OF ALLOYS.

	Special Element %	C %	Mn %	Si %	S %	P %	Al %	Fe %	Specific Gravity
Iron rolled.....	99·87	0·04	0·02	0·03	0·02	0·02	0·00	99·87	7·8477
Iron cast.....	99·82	0·08	0·01	0·04	0·03	0·02	0·00	99·82	7·8478
Nickel.....	1·51	0·11	0·09	0·03	0·03	0·02	0·02	98·39	7·8588
Manganese.....	1·29	0·10	1·29	0·37	0·02	0·02	0·03	98·17	7·8269
Copper.....	1·81	0·10	0·08	0·04	0·02	0·02	0·03	97·90	7·8661
Chromium.....	1·10	0·17	0·02	0·02	0·02	0·02	0·03	98·62	7·8486
Tungsten.....	1·41	0·08	0·14	0·02	0·02	0·02	0·02	98·29	7·9141
Aluminum.....	1·85	0·03	0·04	0·05	0·02	0·02	1·85	97·99	7·6756
Silicon.....	1·94	0·08	0·11	1·94	0·02	0·02	0·06	97·77	7·7328
Arsenic.....	1·57	0·04	0·01	0·03	0·02	0·03	0·03	98·28	7·8690
Phosphorus.....	1·36	0·07	0·02	0·03	0·02	1·36	0·03	98·47	7·7978
Sulphur.....	0·97	0·08	0·00	0·03	0·97	0·02	0·03	98·85	7·6903
Tool Steel.....	1·35	1·35	0·28	0·08	0·02	0·02	0·04	98·21	7·8128

in behavior of elements like manganese and nickel, in accordance with percentages used.

Experiments have been made combining several elements in a steel. A. Abra-



Curves showing the characteristic effect of various elements on iron and steel, constructed from data given by Prof. J. O. Arnold, in the *Journal of the Iron and Steel Institute*, 1894, No. 1, p. 118.

ham* tested steel alloys containing nickel, chromium, and silicon in large percentages, which were made at Imphy under the direction of the naval authorities of France. The most important alloy mentioned under this article is called Nc4, and contained 0·55 to 0·80% C, 0·20 to 0·50% Si, 0·30 to 0·60% Mn, 2 to 3% Cr, 0·20 to 0·25% Ni. This steel tested after forging and without further treatment has an elastic limit of 31 tons (69,440 lb.) per sq. in., tensile strength 44·5 tons (99,680 lb.), elongation 45% (number of inches not mentioned). In this condition its flexibility is deficient. When subjected to water quenching from a cherry red the elastic limit is reduced to from 19 to 22 tons (42,560 to 49,280 lb.). But elongation increases to 60% and is about uniform throughout the entire length of the specimen. Waste by corrosion is extremely slight. Forgings made from this steel are very rough and scaly, so that a very deep machine cut is necessary. This quality has proved a serious objection to this steel.

Another steel mentioned is N 12·5, containing from 12 to 12·5% Ni, 0·75 to 1% Cr, 0·30 to 0·45% C. This is a much harder steel, but is very brittle, breaking without stretch, and therefore not suited to sudden strains in its forged condition. Annealed in a flaming wood fire the steel makes good forgings, having an elastic limit of more than 51 tons (114,240 lb.) and a tensile strength of 63·5 tons (142,240 lb.).

The Alloys.

Aluminum and Iron.—Aluminum has taken a prominent place in commercial uses quite recently and it was believed that it might be used to alloy with iron. It alloys with it in all proportions, but is not normally found associated with it. Many attempts were consequently made, but up to the present time it has proved to be more useful during the process of manufacture of steel than in the steel itself. In connection with cast iron it has been used to produce solid castings. It oxidizes so readily that any free oxygen in its presence is at once taken on by the aluminum with a resulting more sound casting. This remark applies to its use in connection with the casting of steel ingots or steel castings. In this respect aluminum does no more than silicon would do, could silicon be obtained 98 or 99% pure. But as it is, silicon is always associated with carbon, which when added to the molten steel gives off some gas, to the detriment of the resulting metal. The presence of aluminum in finished steel has not proved beneficial. It adds nothing to the strength and destroys the toughness to a considerable degree.

Arsenic and Iron.—Arsenic unites readily with iron in all proportions and behaves toward iron much as sulphur does. It exists in steel oftentimes in very small quantities, so small as to be negligible. Arsenic has been found very often in ancient cannon balls, the iron being very hard and brittle. One of these contained as much as 16·20% As. It lowers the saturation point for carbon in cast iron and gives iron a white fracture. When it enters forged iron or steel it makes it extremely red-short and in large proportions cold-short as well.

Carbon and Iron.—The effect of the element carbon alone when alloyed with iron it is practically impossible to give, because it has been impossible to make

* *Annales des Mines*, Vol. XIV., 1898.

an alloy with carbon as absolutely the only addition. With small amounts of several other elements present it cannot be claimed that the influence of carbon alone is known. Small amounts of the ordinary elements (even two or three hundredths of a per cent.) in the presence of carbon exert very great influences. Nevertheless it is certain that carbon alloyed with iron (commercial) strengthens it in its normal annealed condition and causes it to become hard after being heated and suddenly cooled. The amount of carbon that pure iron will absorb before saturation is somewhat in dispute, 4·8% is probably the saturation point. The addition of 5% has been attempted several times, but has failed. Some Nova Scotia iron containing titanium and free from silicon was found to contain 4·65% and seemed to be nearly pure carbide. As the percentage of silicon increases in iron the amount of carbon that will be absorbed decreases. With 20% Si no carbon is absorbed. Carbon is incorporated with iron (as steel) for commercial purposes in amounts from 0·04 to 2·0%. Such alloys are what is known as carbon steel,—the ordinary steel of commerce. Larger percentages of carbon exist normally in cast iron, some 3 or 4%.

With carbon in cast iron is associated much silicon and small amounts of sulphur, phosphorus, manganese and copper. As mentioned in the foregoing paragraph it is known that silicon and carbon have a mutual influence upon each other, the amount of silicon determining very largely in what form the carbon exists; in the graphitic form, not in chemical combination; or as carbon chemically combined with iron in the form of a carbide of iron.

Carbon alloys in still greater quantities, as high as 7%, when associated with iron and manganese. Manganese increases the dissolving power of the iron as regards carbon, and for this reason a 20% Mn iron alloy, known to the trade as "spiegel," contains a large percentage of carbon (7%). This characteristic is taken advantage of by the steel maker when it is desired to increase the amount of carbon in molten steel. In most cases manganese, as well as carbon, is needed at such times and spiegel furnishes both. When it is desirable to add carbon only, molten pig iron is used, or carbon in the form of coke or charcoal is intimately mixed by mechanical means with the molten metal and is absorbed by it.

Carbon is the most important element alloyed with iron, because of the useful character of alloys resulting. In small amounts, say up to 0·25%, the steel is used for structural and manufacturing purposes, where a soft, malleable, tough material is required, having an elastic limit as high as 40,000 lb. per sq. in., with an elongation in 8 in. in the neighborhood of 25% and a reduction of area of 50%.

The next harder class of carbon steels may be said to include alloys containing from 0·40 to 0·60% C. Such material is used for structures and parts of machinery, where the strain is very great, where immense strength is required and where the steel is ordinarily used in its normal annealed condition. Railroads undoubtedly consume the greatest tonnage of this grade for rails. Much is used for table cutlery of a low grade, some of which is hardened by quenching and some not. Such steel has an elastic limit of about 75,000 lb. per sq. in., with an elongation in 8 in. of about 10% and a reduction of area of about 20%.

The next higher grade alloy of carbon is almost exclusively used for tools hard

enough to have a good cutting edge. Wood working tools have about 0·80 to 0·90% C. Machine shop tools for cutting metals 0·90 to 1·20%, for the still harder tools 1·20 to 1·50%, including files and razors, and just above this point for surgical tools.

It must not be understood that carbon is the only element present besides iron. Associated with it are appreciable amounts of phosphorus, manganese, sulphur and silicon. The less of these elements the more expensive and of better quality is the steel. This refers especially to phosphorus and sulphur. Manganese is added to overcome the ill effects of phosphorus, and sulphur and silicon find their way into the steel during melting and are of little importance in small quantities. So accurately has the effect of carbon been determined that it is perfectly safe to estimate an increase of 1,000 lb. per sq. in. tensile strength in steel for every addition of 0·01% between limits of 0·10 and 0·40%. Steel shows the effect of carbon (in respect to hardening after quenching) in very small amounts. That containing from 0·20 to 0·35% stiffens materially when quenched at a low red heat, but no cutting edge results. From 0·40 to 0·60% carbon the steel becomes very much harder and brittle in its quenched condition. Thin edges like a table knife harden so as to give a fair cutting edge. At 0·75% and over a cutting edge of high quality begins, when the steel is quenched at low temperatures.

Chromium and Iron.—Chromium has been added to iron as an alloy for many years and its effect is closely similar to that of manganese in moderate percentages. Chromium will combine with iron in all proportions and tends to raise the saturation point of carbon. Ferrochrome is a common article of commerce containing 80% Cr and is used in the production of chrome steel, being added to the steel in crucibles. Unlike manganese, chromium is only removed from the pig iron, if it exists, during the process of steel making by the basic process. For this reason the ordinary Bessemer steel made from ores containing some chromium sometimes contain a small amount, which is not noticeable in the behavior of steel during working or in subsequent use. Chromium in steel very seriously interferes with welding properties. It forms a persistent scale which seems to prevent welding, and the result is only of an adherent nature. It is not certain that chromium increases the tensile strength of steel, nor the elastic limit. Neither is the ductility, as represented by elongation and reduction of area, greatly effected.

It is not of commercial importance in cast iron. It is added to steels that command a high price, but is not used probably in such large commercial industries as nickel and manganese have been. It makes an excellent alloy for armor and armor piercing projectiles. Commercial chrome steels for these purposes contain from 1 to 4% Cr associated with from 0·8 to 1% C. When it is without carbon it does not harden, but associated with carbon it causes an intense hardness. The annealed steel is very difficult to machine.

There has been on the market* for some time past a refined ferrochromium containing 65 to 70% Cr, with from 0·50 to 1% C, which is very readily fusible. This alloy has been employed to a considerable extent for bullet-proof steel, projectile steel, etc. The mechanical properties of these steels are shown in the following table, the carbon content being constant at about 0·4%:

* *Iron and Coal Trades Review*, Oct. 5, 1900.

Chromium.	Condition.	Elastic Limit.	Breaking Stress.	Elongation.	Contraction. (*a*)
%		Tons per sq. inch.	Tons per sq. inch.	%	
5	Annealed	17·8	31·8	24·0	0·240
	Hardened and Tempered	48·8	55·2	12·0	0·370
10	Annealed	22·9	42·0	21·5	0·440
	Hardened and Tempered	42·4	54·3	12·0	0·536
15	Annealed	25·4	45·3	18·5	0·500
	Hardened and Tempered	48·8	58·1	11·5	0·546
20	Annealed	21·2	36·1	21·5	0·465
	Hardened and Tempered	27·6	40·3	19·5	0·515
25	Annealed	29·8	42·2	18·0	0·621
	Hardened	27·6	40·4	20·0	0·500
30	Annealed	31·8	41·6	19·0	0·620
	Hardened	28·8	39·0	19·0	0·650

(*a*) Ratio of fractured to original section.

The success of high chromium steels is mainly due to the low percentage of carbon in them, and steel makers are beginning to see the advantageous results of making steels of this character, which are particularly adapted for the manufacture of stamp heads in milling quartzose gold ores, and to all purposes where an exceedingly hard and tough steel is required.

It is now commonly used in tool steel because of beneficial results, but steel so alloyed must be treated with the greatest care in hardening. It has been more or less used in connection with safe and vault construction and jail work, but does not possess the peculiar resisting qualities that the manganese alloy possesses, and can be machined only with great difficulty and therefore cannot be easily worked by safe breakers.

Cobalt and Iron.—But few attempts have been made to alloy cobalt. The one most fully recorded was made by Mr. R. A. Hadfield who reports that the alloys resemble those of nickel to a great degree. A 1·8% alloy not annealed had a tensile strength of 41 tons (91,840 lb.) per sq. in., with 19% elongation in 2 in. The same steel after annealing had a tensile strength of 35 tons (78,400 lb.) per sq. in. with 29% elongation. Alloys containing higher percentages are very malleable and have a higher elastic limit than is possessed by carbon steel.

Copper and Iron.—Copper alloys readily with iron, but with no good results at any percentage. It is found in small amounts in cast iron and steel, say 0·5%, the amount varying with the locality from which the ore originally came, some ores being entirely free from copper and others not. A. L. Colby has investigated the effect of copper on steel and concludes that it is safe up to 1%, providing sulphur is not high also. In any case copper makes itself felt only in connection with the behavior of the steel while hot. The physical properties when tested cold are precisely the same as if no copper were present. Tests were made to show that steel for Government uses would meet specifications without difficulty when the percentage of copper was as high as 0·5 to 0·6%. It is certain that copper in small amounts, up to 0·5%, when associated with ordinary amounts of sulphur, say 0·06 or 0·08%, in soft steel proves a very great enemy to its welding properties. This has been particularly noticeable in connection with soft steel for butt- or lap-weld tube skelp. It is the most difficult element normally found with iron to eliminate from the finished product.

Manganese and Iron.—It is difficult to name the alloys in the order of their importance from this point on, as each one possesses some field in which it is all important, and the degree of importance is not comparable. Manganese steel

is certainly of very great importance now and is finding new uses in a large way continually. The comparatively low cost of manganese as an alloying element, as compared with some of the rarer elements, will certainly assist in pushing it to the front as an important commercial product. It is commonly found in cast iron in small amounts, but is eliminated during steel making operations, only to be added again at will.

Manganese alloys with iron in all ratios, the alloy of 80% Mn with iron being an important commercial article in connection with steel making. Still greater tonnages of 10 and 20% alloy (spiegel) are used for the same purpose. The presence of manganese increases the power of carbon to combine with iron and tends to prevent the separation of graphitic carbon during cooling of pig iron. Manganese is ordinarily added to steel to counteract the ill effects of the hot-short elements, sulphur and copper, and is almost indispensable in connection with the manufacture of steel for these reasons. It does not counteract the effect of the cold-short element, phosphorus, but up to 1% is in no case detrimental to steel below 0·50% C, except that it hardens the softest grades. It is kept down to about 0·30% for this reason. For steel above this point and below 0·85% a class which is ordinarily hardened for springs or cheap tools, manganese above 0·80% is distinctly injurious, as it tends to cause the steel to crack during the hardening process, causing what are commonly called fire cracks. In soft machine steels, such as are used for rapid machining operations like the production of carriage axles, manganese is added to give a physical characteristic tending to make the metal cut cleanly and easily. This is necessary only with steels containing phosphorus below 0·80% and carbon below 0·16 to 0·18%, which are otherwise too soft to cut cleanly. This precaution is not necessary with steel high in phosphorus, as that element gives a similar physical characteristic in regard to cutting, and for some trades, such as screw making, the high phosphorus stock is much sought after. Steel of unusually pure quality may be made and worked successfully without the addition of manganese, but it is rare to find any steel, even of the best high-grade carbon stock for tools, that contains less than 0·15 or 0·20% Mn, but the phosphorus and sulphur in such steel is very low, both being commonly below 0·03%.

Manganese plays a very useful part during the casting of steel into the ingot form. It is added immediately before casting and very materially assists in producing solid ingots free from blow-holes by combining with the gases present or increasing the solubility of the gas in the steel. Manganese, like nickel, behaves very differently in its effect upon iron in accordance with the amount added, and gives alloys which are anomalies in their way. Mixtures containing from 3 to 6% Mn with not over 0·60% C are brittle and hard, and are useless as far as commercial value goes.

Mn 9·8%, C 0·72%, Si 0·37%, S 0·06%, P 0·08% gives a steel with a tensile strength of 106,049 lb. per sq. in., with an elongation in 8 in. of from 22 to 28·9%. Nine to ten per cent. manganese steel can be machined but with difficulty, and higher percentages can hardly be cut at all. Commercial alloys called manganese steel contain from 9 to 15% Mn. The metal casts nicely and, when suitably treated, has unusual advantages in a combination of hardness and tough-

ness of the kind that resists abrasion. It is almost impossible to machine the steel, and yet it does not possess the glass-hard characteristics of ordinary hard steel. For example, it can be dented by a machinist's hammer. The alloy can be easily forged and after suitable heat treatment possesses a tensile strength of from 60* to 70 tons (134,400 to 156,800 lb.) per sq. in. with an elongation of 35 to 40%. The heat treatment consists in quenching from a very high temperature. Its characteristics after forging are much the same in their peculiarities as after casting, although, as would be expected, the metal is a stronger and better one after being worked.

Uses to which manganese steel is now put are those where its peculiar combination of hardness and toughness are much needed. One of the early and still important uses is for the jaws of rock crushers. The steel resists the wear and tear of such work better than anything else and without the risk of breaking, which accompanies the use of ordinary hard steel or chilled iron. Brake shoes of manganese steel stand up remarkably well. Mine car wheels constantly subject to excessive abrasive action are made of it. It is now being used to manufacture what is without doubt the most burglar-proof safe on the market. The metal resists the tools of the burglar and shocks of dynamite to a wonderful degree.

Molybdenum and Iron.—Similar to tungsten in nature is molybdenum and a series of experiments by Mr. R. Helmhacker* was conducted as comparison between tungsten and molybdenum. The alloys made contained 3·8% W and 3·7% Mo; in all other respects the steels were exactly similar. It was found that the molybdenum steel was somewhat the softer of the two and common tempering methods had greater influence upon the tungsten steel than upon it. But the molybdenum steel was stronger and less brittle than the tungsten steel after heating and quenching in water. The tungsten steel was more apt to split when worked and broke more easily when bent cold. The alloys were in many respects very similar, but the molybdenum steel stood heat treatment the better of the two. Positive information is lacking, but it is believed that both tungsten and molybdenum are used extensively by Krupp in the manufacture of armor plate.

Nickel and Iron.—Following the importance of carbon as a commercial alloy for iron it is probable that nickel stands next. Nickel alloys with iron very easily in all amounts up to some 50%. It is not ordinarily found with nor used in cast iron. The effect of the nickel varies very greatly in character with the amount added. Alloys obtained with percentage less than eight have all the toughness of the best carbon steel and considerably more strength, combinations of toughness and strength being obtained that are not rivaled by any metal for commercial uses. Armor, steamship shafts, heavy engine shafts, and in fact any parts where unusual strength and reliability are demanded are made of it. After passing 8% the alloys are brittle and of no use up to about 22%. At this point their character changes again and an alloy is obtained which is more or less used in the arts, being non-magnetic, non-corrosive and possessing a very low coefficient of expansion, qualities particularly suited to the construction of instruments. These alloys, although good in their physical characteristics, are naturally barred from large commercial uses because of the high price of nickel.

* *Engineering and Mining Journal*, Oct. 8, 1898.

Nickel steel in the United States is made in immense quantities by the open-hearth process. The nickel is added in the form of the oxide, which is put into the furnace just previous to the tapping of the heat. A small percentage is thus lost in the slag, but not a serious amount. In Europe much nickel steel is made by Krupp and others in crucibles; immense numbers of them being poured simultaneously to give the necessary weight for the largest of gun tubes or armor plates. In this case the nickel is added in the crucibles in the metallic form 98 to 99% pure. The increase in cost of nickel steel over carbon steel is in proportion to the amount of nickel added. At 35c. per lb. metallic nickel it amounts to about 0·33c. per pound of metal produced. During forging operations nickel steel scales and wastes much more than carbon steel. Small forgings cannot be made as close to finished size because of the heavy scale resulting.

The alloys of iron and nickel used for structural purposes contain from 3 to 4% Ni, associated with about 0·25% C, with the phosphorus below 0·04% and the manganese about 0·50%. Nickel steel of this composition has an elastic limit of about 40,000 lb. per sq. in., 80,000 lb. per sq. in. tensile strength with about 23% elongation and 45% reduction of area. This same alloy after quenching and tempering will have an elastic limit of about 60,000 lb. per sq. in., tensile strength 90,000 lb. per sq. in. with about 22% elongation and 50% reduction of area.* The above figures are what is obtainable ordinarily for common nickel steel forgings, and by suitable treatment may be increased to a very great degree. Many of the forgings made by the Bethlehem Steel Co. have had a tensile strength of over 250,000† lb. per sq. in. an elastic limit of from 150,000 to 175,000 lb. with a reduction of area of nearly 35 to 40% and 12 to 14% elongation. Much 5% nickel steel bicycle tubing has been so treated as to have a tensile strength of 240,000 lb. per sq. in. with 4% elongation in 10 in., and sufficient ductility so that the tubing could be flattened to about one-half diameter before cracking.

Nickel steel is remarkably sensitive to all forms of heat treatment. In the condition that it drops from the rolls or is taken from the hammer and allowed to cool in the air it is often found very difficult to machine, as it seems to air harden enough to resist the cutting tool to a troublesome degree. This is especially true of small parts. This objectionable feature may be removed and a good, keen, easy-cutting metal be obtained by annealing the steel at a very low red heat and allowing it to cool out of contact with cold air. Much complaint has been made of nickel steel for this reason, and in many cases it has been rejected where its otherwise excellent qualities would have been much appreciated. Nickel steel should be handled with the greatest of intelligence, and not treated as it has always been the custom to treat ordinary blacksmiths' iron and machine steel. Nickel tool steel is being put upon the market and meets with success among consumers that appreciate the great degree of carefulness necessary in handling it. As with the lower carbons, it makes the steel more sensitive to heat treatment, but with proper heat treatment it gives results not surpassed.

Nickel and iron alloys were dealt with in THE MINERAL INDUSTRY, Vol. VIII., and the developments since that time have not been of a notable character.

* THE MINERAL INDUSTRY, Vol. VIII., 1900, p. 445. † Maunsel White. Bethlehem Steel Co.

Phosphorus and Iron.—Phosphorus unites with iron in proportions up to about 26% and is readily absorbed by iron when brought in contact with it. Nearly all the phosphorus contained in the ore remains with the iron and appears in pig iron. Its presence in cast iron is of comparatively little importance, when compared with the effect of silicon and sulphur. One of its effects is to limit its use for steel making purposes, as above 0·1% it is not available for the Bessemer steel trade, except in special cases. Above that limit and as high as 1% the pig iron goes to the foundry. Above 0·6 or 0·7% phosphorus causes cold shortness in cast iron and to get a good, strong, tough iron the phosphorus should be kept below 0·5%. In cases where unusual fluidity is a necessity and strength and toughness do not come into the question, phosphorus is sometimes used and gives the desired effect in the neighborhood of 0·9%.

In structural steels the phosphorus limits ordinarily specified vary in accordance with the nature of the work the steel must do and the price possible to pay under existing commercial conditions. Steel of the ordinary Bessemer grade, such as is used for rails and nail plate, contains from 0·07 to 0·10%. This is what is ordinarily recognized as Bessemer grade. For important bridges the specifications usually limit the phosphorus in acid steel to below 0·08%, in basic steel to below 0·05 or 0·06%. In high-grade rivet steel or fire-box steel, in fact for any steel demanding the very best of structural characteristics, the upper limit is ordinarily 0·035%. Percentages lower than this are very common in the best of basic steel and it is not unusual to find low carbon steel containing from 0·005 to 0·02%. Such steel as this is commonly known to the trade as "extra dead soft basic," the carbon being about 0·06%. Large quantities of this grade go into horse shoe nails and the highest grade boiler tubes.

The steel containing the largest percentage of phosphorus that is common to the trade goes into sizes suitable for automatic screw machines where the ease of machining and the possible speed attainable is the most desired result. Steel containing from 0·10 to 0·20% P is common for this class of work. The product leaves the machines in a beautiful condition, as far as appearance is concerned, being very smooth and of a fine, bright finish. The parts made from such stock are necessarily inferior to what they would have been if the phosphorus had been lower. Broken screw heads and bolts that twist off easily are the practical results of this practice.

The basic process of steel making is valuable because it removes phosphorus. Pig iron containing as high as 1% P may be melted into steel by the basic process and the phosphorus reduced to commercial limits economically. Immense quantities of ore otherwise worthless have been made available by this means. The Southern ores are largely of the high phosphorus variety.

Silicon and Iron.—Silicon associates itself with iron in the blast furnace and is the all important element in pig or cast iron. It alloys with iron in all percentages up to 30. It determines to a great extent of what grade the pig iron is and consequently to what uses it shall be put. Silicon is always associated with steel in moderate quantities and is now being experimented with in considerable percentages.

The mention of one grade of silicon steel is made under some experiments

conducted by the French naval authorities. It contained carbon from 0·26* to 0·43% C; from 1·52 to 1·65% Si; from 0·63 to 0·82% Mn. It is stated in the report on the experiments that this steel has been used to a considerable extent for high class railroad springs, after rolling into flats 60×5 mm. to 150×12 mm. It is tempered by heating to a cherry red and cooling in water to 300° C., then reheated in flaming wood fire and allowed to cool slowly in the air. Tested in 4-in. lengths in this condition the elastic limit is 70 tons (156,800 lb.); tensile strength 79·5 tons (178,080 lb.); 7 to 9% elongation, fracture fibrous. Sound ingots large enough to make armor plates have not been obtained. Hadfield has found that 2% Si with 1% C hardens and produces a steel very similar to tungsten or chromium steel, not quite as hard, but much tougher. This alloy is still in the early stages of experiment.

Sulphur and Iron.—Sulphur unites with iron in all proportions, and is absorbed by it with very great readiness from the fuel or other sulphur-containing substance with which it is brought in contact while hot. Sulphur in pig iron or cast iron influences its fracture to a commercial extent, by causing carbon to combine with iron more readily, and, because of its harmful action upon steel, naturally cheapens the value of any iron in which it is found to any appreciable degree. The amount of sulphur found in good grade tool steels is usually very small, seldom over 0·03% or possibly 0·04%. If above this limit a steel of so high carbon as tool steel necessarily is, would prove too tender during forging. With lower carbons, as is used for structural purposes, a large amount of sulphur is allowable and commonly found. It varies in amount in different districts and depends largely upon the nature of the ore from which the iron or steel has been made. Throughout the State of Pennsylvania the ordinary sulphur content of Bessemer steel is about 0·07%. In some districts it is as low as 0·04 or 0·05%. If small quantities only of copper are present, say below 0·05%, neither of the amounts need cause any trouble, providing the ordinary percentage of manganese is present, say about 0·40%. If, however, the copper is as high as 0·20 to 0·50% the steel will be very sensitive while hot and not weld readily. This is particularly noticeable in connection with the manufacture of welded tubing. Steel very low in copper, but containing 0·10% S, welded better than steel with 0·04% S and 0·20% Cu.

High grade structural steel, such as is used for boiler fire boxes should contain a minimum amount of sulphur, so that the steel may safely resist the high temperatures that are necessary during the forming of the fire-box plates and also an occasional overheating when in use. Some of the very best basic open-hearth steel is wonderfully low in sulphur, instances being common where it is only 0·005 to 0·01%. The stock used in making such steel is of the ordinary Bessemer quality containing say 0·07% S. This amount is reduced to the above mentioned percentage by the action of the basic slag and by addition of manganese to the bath of steel toward completion of the melting. In forgeable blacksmiths' iron more sulphur can be tolerated than in steel, but a good iron should not contain more than 0·05 or 0·06%. The best of Swedish iron is very much lower than this and contains usually from 0.01 to 0.02% S.

* *Transactions of the Institute of Civil Engineers.*

The commercial limit for sulphur in steel is commonly regarded as being below 0·1%. Sulphur can only be removed from steel during its manufacture in a commercial way in the basic open-hearth furnace by the liberal addition of manganese. Even this method will not entirely remove it. Sulphur makes the steel red-short and must be kept out of all high grade steels.

Titanium and Iron.—Titanium is found in iron ores, but seldom reaches the finished product, as it is readily oxidized and passes into the slag of the blast furnace. Until a very recent date it has been looked upon as a deleterious element in both pig iron and steel, but is now being experimented with on a large scale for the production of a special grade pig iron and steel.*

Tungsten and Iron.—Tungsten does not associate itself with iron normally and is of no importance in cast iron. It will alloy in all proportions up to 80%. Tungsten was one of the very early rare elements added to carbon steel to increase its hardness, and tool steel containing this element has been on the market for a great many years under the name of "Mushet Steel," of the self-hardening variety. Tungsten steel is made by the crucible process, the tungsten being added as ferrotungsten in the crucibles.

The effect of the tungsten on structural steel is somewhat in doubt, but there are certainly no gains of sufficient importance to compensate for the cost of this expensive alloying material. Bars of steel containing carbon in the neighborhood of 1% associated with the tungsten are very brittle, often breaking under the blow of a sledge, or even from excessive chattering when made into a tool.† Tungsten can be best worked by forging at a temperature between a cherry red and low yellow. It is with very great difficulty welded, although some specimens have been perfectly welded by the electric process.‡ Such steels commonly contain from 2 to 10% W, associated with 1 to 1·5% C. This alloy cannot be machined and must be brought nearly to shape by forging, then to a finish by grinding. No quenching treatment is necessary to cause it to maintain a good cutting edge. Even in its annealed condition it can hardly be cut with a new file. This steel and a high grade chrome steel are of a similar hardness and scratch glass easily. It is remarkable that the best steel for permanent magnets is one containing about 7·5% W of normal composition in other respects.

Vanadium and Iron.—Attention is called to the remarkable malleability and ductility of alloys containing vanadium. An addition of 0·5% V to ordinary malleable iron of about 24·5 tons (49,000 lb.) tenacity and 19% elongation, gave 39 tons (78,000 lb.) tenacity and 12% elongation in the forged bar and 33·7 tons (67,400 lb.) and 32% elongation after annealing. A mild steel of 30 tons (60,000 lb.) tenacity and 17% elongation gave, with 1% V, 61 tons (122,000 lb.) tenacity and 14% elongation, and when annealed, 45 tons (90,000 lb.) tenacity and 20% elongation; these alloys although very soft when annealed, become very hard by tempering. It is stated that a large supply of vanadium would admit of its use in the manufacture of steel for armor plate, forgings for ordnance and naval machinery, projectiles, and tools.§

* Consult the special article on "Titanium and Its Alloys," elsewhere in this volume.
† H. M. Howe, "Metallurgy of Steel." ‡ *Idem.*
§ *Engineering and Mining Journal*, Aug. 18, 1900, p. 192.

LEAD.

THE production of lead in the United States during 1900 showed a remarkable increase over the production in 1899, exceeding by 47,432 tons the record figures of 1898. The grand total of soft, desilverized and antimonial leads produced from both domestic and imported ores and refined from imported base bullion in 1900 amounted to 344,052 metric tons (379,248 short tons) against 266,269 metric tons (293,508 short tons) in 1899. The totals of desilverized, soft and antimonial leads in short tons, derived from domestic ores in 1900 and 1899 were respectively as follows: Desilverized, 221,278, 171,495; soft, 47,923, 40,508; antimonial leads, 6,706, 7,337; total domestic leads, 275,907, 217,085.

PRODUCTION AND CONSUMPTION OF LEAD IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Stock of Refined, Jan. 1. (a)	Produced from United States Ores.				Imported in Ores and Bullion.	Total Supply.	Consumed.	Exported in all Forms.	Stock of Refined, Dec. 31. (a)
		Desilverized.	Soft.	Antimonial.	Totals.					
1896....	18,975	135,332	33,428	*b* 5,932	174,692	80.159	273,826	203,819	56,983	13,024
1897....	13,024	144,649	45,710	*b* 7,359	197,718	92,117	302,859	211,345	60,353	31,161
1898....	31,161	169,364	50,468	*b* 8,643	228,475	89,209	348,845	246,989	78,168	23,688
1899....	23,688	171,495	40,508	7,377	217,085	76,423	317,196	215,662	74,944	26,590
1900....	32,320	221,278	47,923	6,706	275,907	103,341	411,568	244,640	100,288	66,640

(*a*) Includes lead in bond, which amounted to 21,190 tons at the end of 1900, 11,320 tons at the end of 1899, 7,345 tons at the end of 1898, 6,694 tons at the end of 1897, and 4,124 tons at the end of 1896. (*b*) The entire production of antimonial lead is entered as of domestic production, although part of it is of foreign origin; it is, however, impossible to separate this in the statistics; owing to this inability the division of the American production between antimonial and desilverized is not quite accurate, though the error is not important. (*c*) Estimated.

The increase in the production of domestic lead during 1900 was due to various causes. In soft lead the mines of southeast Missouri showed considerable gain and in argentiferous lead the mines in the Cœur d'Alêne district, Idaho, showed a remarkable increase, while the production in Colorado also was larger than in 1899. In the amount of lead obtained from foreign ores there was a large increase which was derived mainly from Mexico, though the mines of British Columbia furnished a considerable supply.

An important event in the mineral interests of America and of the world was

the recent consolidation of the firm of M. Guggenheim's Sons with the American Smelting & Refining Co. This move, initiated in the last months of 1900, was consummated early in 1901. The property turned over by the Guggenheims to the American Co. included the smelting works at Pueblo, Colo., and at Monterey and Aguas Calientes, Mexico; the electrolytic refining plant at Perth Amboy, N. J.; various interests in South America; the working capital and cash assets of the firm, and $6,066,667 in cash. In payment for the property thus merged the Guggenheims received stock of the American Co., one-half common and one-half preferred, representing $45,200,000, and valued at the quotation January, 1901, at about $36,000,000. To provide means with which to effect this combination the working capital stock of the American Smelting & Refining Co., which comprised $27,000,000 in common and $27,000,000 in preferred stock, was increased to $100,000,000. The report of this company for the fiscal year ending April 30, 1900, showed a profit of $3,524,961. Dividends to the amount of $1,545,043 were paid. It is claimed that the consolidated company will handle 65% of the world's output of silver, and thus will be able to hold up the price of this metal to a percentage much above its values in recent years.

Colorado.—The American Smelting & Refining Co. has made many improvements at the Arkansas Valley plant, which was the only one of its three plants in the State in operation toward the end of the year. Extensive double-section dust chambers have been added which cause the furnace gases and fumes to travel nearly a mile in the passage to the chimney and two additional smelting furnaces have been built. The production of lead in this State during 1900 was 82,137 short tons, valued at $7,770,196, against 69,024 short tons, valued at $6,170,766 in 1899. The production by principal counties for the two years as reported by the Hon. Harry A. Lee is given in the subjoined table:

County.	1899.		1900.		County.	1899.		1900.	
	Short Tons.	Value.	Short Tons.	Value.		Short Tons.	Value.	Short Tons.	Value.
Clear Creek	3,608	$322,567	2,497	$236,229	Pitkin	12,729	$1,137,989	13,726	$1,289,492
Hinsdale	5,286	472,484	4,689	443,535	San Juan	8,006	715,722	8,789	831,495
Lake	24,299	2,172,363	31,300	2,960,964	Others	8,479	758,001	8,921	843,914
Mineral	2,839	253,769	7,476	707,227					
Ouray	3,778	337,770	4,739	448,340	Total	69,024	$6,170,765	82,137	$7,770,196

Idaho.—The production of lead in the Cœur d'Alêne district in 1900 was 81,535 short tons, against 50,006 tons in 1899. The output of silver in 1900 was 4,755,877 oz., against 2,736,872 in 1899. The statistics of silver and lead production in this State are based on direct returns from the mines, with an allowance of 6% for loss of lead in smelting and 2% for loss of silver. There are five important producers in the Cœur d'Alêne district who mechanically concentrate the low-grade ore to a product averaging about 50% Pb and 30 oz. silver per ton. The Buffalo Hump Mining Co. has sold the Tiger & Poorman mine at Burke to the Empire State-Idaho Mining & Development Co., who increased its capitalization from $1,000,000 to $6,000,000. The Buffalo Hump Mining Co. reduced its capitalization from $3,000,000 to $1,000,000 and has confined its operations to gold properties in the Buffalo Hump district.

Iowa.—The production of lead in the mines at Dubuque and vicinity during 1900 was about 400 tons, most of which was smelted at Dubuque.

Missouri.—Southeastern Missouri remains the only large lead producing district in the country, of which the output is not controlled more or less directly by the American Smelting & Refining Co. The area in which the lead ore has been discovered is about 35 miles long and about 12 miles broad. Miners receive from $1·50 to $1·75 per day; common labor is paid $1·25. Wood costs $1·50 to $1·75 per cord. Coal costs 95c. per ton at East St. Louis, whence the freight rate to Flat River is $1·05, the cost of coal delivered at the mines being $2 to $2·50 per ton. Common lumber costs $15 to $17 per thousand. In the larger mills the cost of dressing is between 20 and 30c. per ton. In general the ore yields about 7% of galena concentrate which averages about 66% Pb, although some mills make products assaying as high as 73%. For the most part the concentrated mineral is smelted by the mining companies which produce it. The Desloge Lead Co. employs the reverberatory process of smelting; the others smelt with circular water-jacketed furnaces, with a flux of limestone and ironstone, the ore having been previously slag-roasted or sintered in reverberatory furnaces. Coke is used for fuel. The cost of smelting is reckoned generally at about $8 to $10 per ton. Within two or three years, however, the St. Louis Smelting & Refining Co. has smelted concentrates at a charge to the miner of $6 per ton. The freight on pig lead from the Flat River mines to St. Louis is $2·10 per 2,000 lb., and lead from those mines which are best equipped can be laid down at St. Louis at a cost of about 2·25c. per pound. The largest producers of lead in southeastern Missouri are the St. Joseph and the Doe Run companies, and after them rank the Desloge, Picher, Central, Columbia and Mine la Motte. The St. Louis Smelting & Refining Co., which is a branch of the National Lead Co., has equipped its mines at Desloge with a modern electric plant which furnishes power to hoist the ore from the mine and to run the mill. The works have a capacity of 1,000 tons a day. The total production of pig lead in southeastern Missouri in 1899 was 31,355 tons, and the production in 1900 is estimated at 34,500 tons. In the Joplin district the average monthly prices for lead ore per 1,000 lb. in 1900 were as follows: January, $27·75; February, $27·69; March, $27·45; April, $27·06; May, $25·75; June, $21·55; July, $22·62; August, $23·06; September, $22·90; October, $23; November, $23; December, $23.

Utah.—During the year the American Smelting & Refining Co. operated five smelting furnaces at the Germania plant and increased the number of Brückner roasting cylinders to 20. It reports the following totals for 1900: Gold, 41,332 oz.; silver, 4,613,319 oz.; lead, 47,958,928 lb.; and copper, 5,647,363 lb. The company is erecting an extensive plant at Sandy which, when completed, will handle all its smelting operations. The lead mine owners in Utah endeavored to form a combination with producers in other States for the purpose of upholding the price of lead. The organization, however, was not perfected.

Washington.—The Puget Sound Reduction Co., which refines its own bullion, reports a diminished output for 1900. The Tacoma Smelting Works ships its bullion to the Selby Smelting and Lead Co. at Selby, Cal., for refining.

Production of Lead in the World.

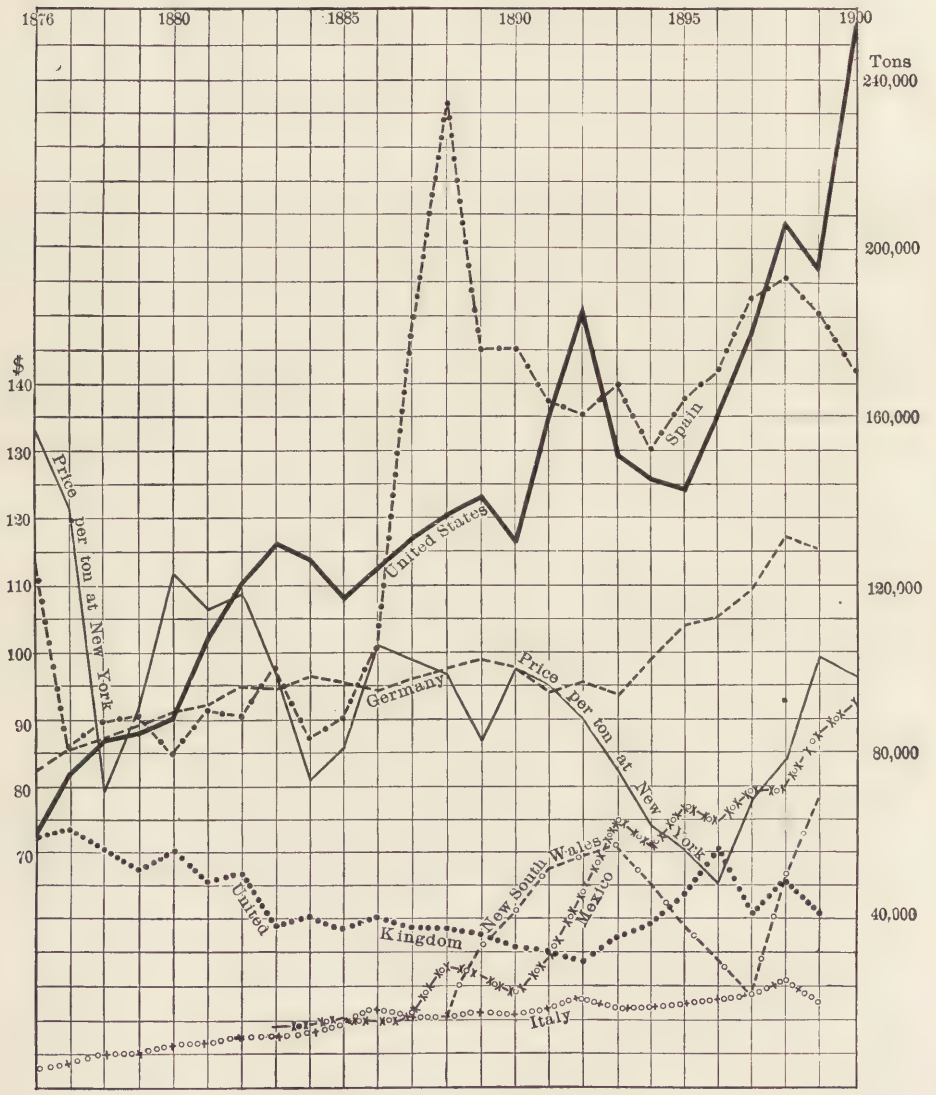
Australia.—The Broken Hill Proprietary Co. reports the following items for the six months ending May 31, 1900: The total amount of ore treated was 121,786 tons which yielded 16,536 tons lead, 337 tons antimonial lead, 2,277,312 oz. silver, and 8,265 oz. gold. The average results per ton were 13·9% lead, 18·70 oz. silver and 0·038 oz. gold. Improvements were made in the concentrating plant and a new roasting furnace and a reverberatory for the treatment of low grade, leady mattes had been added to the smelting plant. Considerable trouble was caused by fine ores, but it is expected that as soon as the new briquetting machines are in operation the furnaces will give better results. The average extraction per ton of ore smelted was 15·91% lead and 20·41 oz. silver. The company is considering the erection of a coke plant, and experiments are still being carried on with magnetic separators with a view of saving the zinc contents of the ore. The average receipts per ton of ore mined were in United States currency $12·64, the expenses $9·76 and the gross profit $2·88. It is intended to connect the works with certain iron mines in South Australia by a tramway, to insure a regular supply of ironstone for smelting purposes. During the semester ending November 30, 1900, 293,451 tons of ore were mined and 2,780,937 fine ounces of silver and 21,855 tons of lead were produced. The gross profit was £167,796, and the net profit was £126,843. Two dividends together amounting to £120,000 were paid. A magnetic separator has been installed at the Broken Hill Proprietary Block 10 mine for the treatment of tailings. The results are not yet conclusive as to its success. The report of this company shows that during the half year ending September 30, 1900, there were treated 72,466 tons of ore, which gave 11,566 tons of concentrates containing 393,611 oz. silver and 7,483 tons lead.

The Tasmanian Smelting Co.'s plant near Zeehan, Tasmania, has been operating since June 30, 1899, and in the following fiscal year produced approximately 3,380 tons of base bullion averaging 141 oz. silver and 0·35 oz. gold per ton; 100 tons of copper matte containing 52% Cu and 430 oz. silver per ton were also produced and shipped to England for treatment. The plant is equipped with modern samplers, crushers, roasting furnaces, a White briquetting press and three blast furnaces made by the Colorado Iron & Steel Co., Denver, Colo., each treating 80 tons per day.

A company has been formed in London for acquiring rights in New South Wales for process of treating sulphide ores. Works have been constructed at Dapto, near Lake Illawarra, of a capacity of 200,000 tons yearly. The electrometallurgical works, at Cockle Creek, near Newcastle, are experimenting with sulphide ores.

The report of The Sulphide Corporation, Ltd., for the fiscal year ending June 30, 1900, states that 42,116 tons of lead concentrates were obtained from 195,720 tons of crude ore. The gross quantity of lead and silver in the concentrates being 26,713 tons of lead and 1,248,779 oz. silver. The cost of production per ton of concentrates was £3 11s. 8d. In addition the company produced 15,226 tons of slimes containing 256,037 oz. silver, 3,202 tons of lead and

3,408 tons of zinc; 39,041 tons of middlings containing 397,778 oz. silver, 3,672 tons of lead, 7,774 tons of zinc, and 99,336 tons of tailings containing 668,453 oz. silver, 5,124 tons of lead, 22,761 tons of zinc. At Cockle Creek 30,908



THE WORLD'S PRODUCTION OF LEAD
IN METRIC TONS

tons of leady concentrates and 8,511 tons of ores and residues were smelted during the year, the balance of the concentrates having been sold. The bullion output was 17,536 tons containing 1,045,238 oz. silver and 14,671 oz. gold. In

LEAD PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria.	Belgium.	Canada.	Chile.	France.	Germany.	Greece.	Hungary.	Italy.
1895	8,085	15.573	7,467	93	7,627	111,058	19,845	2,277	20,353
1896	9,769	17.222	10,977	594	8,232	113,792	15,180	1,911	20,786
1897	9,860	17,023	17,698	370	9,916	118,881	16,486	2,527	22,407
1898	10.340	19,330	14,477	13	10,920	132,742	19,193	2,305	24,543
1899	9.736	15.700	9.917	171	15,981	129,225	19,059	2,166	20,543

Year.	Japan.	Mexico.	New South Wales. (*c*)	Russia.	Spain.	Sweden.	United Kingdom. (*b*)		United States.	Totals.
							Foreign Ores.	Domestic Ores.		
1895	1,950	68,000	38,000	412	160,786	1,256	16,036	29,464	142,298	650,580
1896	1,958	63,000	30,000	262	167,016	1,530	25,889	31,311	158.479	676,662
1897	1,737	71,637	22,000	450	189,216	1,480	13,312	26.988	179.369	721.167
1898	1,705	71,442	50,000	241	198,392	1,559	23,239	25,761	207.271	781,615
1899	1,989	84.656	70,000	*d* 250	184,007	1,606	17,571	23.929	196,938	803.273

(*a*) The statistics for Austria, Belgium, Canada, France, Germany, Hungary, Italy, Japan, Russia, Spain and Sweden are from the official reports of the respective governments except where otherwise noted. Those for Greece are based on the authorities given under the general table of mineral production of Greece in a subsequent part of this volume. Those for the United States are from data collected by THE MINERAL INDUSTRY. Those for the United Kingdom as specified in note *b*.

(*b*) The production of lead in the United Kingdom is given in two columns. One gives the amount of lead derived from domestic ores, the yield of which is calculated at 95%, as reported in the official British blue books. The other column gives the production of lead in the United Kingdom from foreign ores smelted there. These figures, which are not reported in the official blue books, are obtained by deducting the production of British lead from the total output of the lead smelters of the United Kingdom as stated in the *Statistische Zusammenstellungen über Blei. Kupfer, Zink und Zinn* of the Metallurgischegesellschaft. Frankfort-on-the-Main.

(*c*) From the *Statistische Zusammenstellungen* of the Metallurgischegesellschaft, Frankfort-on-the-Main. These figures comprise only the lead exported to Europe and America. The actual production of lead in New South Wales is much larger than shown here, especially in late years, during which there have been large exports to China, but it is impossible to obtain statistics as to what it really amounts to. (*d*) Estimated.

PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION OF LEAD IN THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

		Aust'a-Hungary. (*a*)	Belgium. (*b*)	France. (*c*)	Germany. (*d*)	Italy. (*e*)	Russia. (*f*)	Spain. (*g*)	Switzerland (*h*)	United Kingdom. (*i*)	United States. (*j*)
1898	Production	12,645	19,330	10,920	132.742	24.543	241	198,392	*Nil.*	49.000	207,271
	Imports	9,746	54,867	74,902	47,497	1,431	22,400	*Nil.*	5,405	197,591	81,326
	Totals	22,391	74,197	85,822	180.239	26,074	22,641	198,392	5,405	246.591	288.597
	Exports	545	40,302	3,663	24,867	5,870	*Nil.*	188,264	175	18,964	69,559
	Consumption	21,846	33,895	82.159	155,372	20,304	22,641	10,128	5,230	227,627	219,038
1899	Production	11,902		15,981	129,225	20,543		184,007	*Nil.*	41,500	196,938
	Imports	9,071	60,649	67.149	55,635	3,990		*Nil.*	4,388	201.551	86,016
	Totals	20,973		83.130	184,860	24,533		184,007	4,388	243,051	282,954
	Exports	258	41,618	3,909	24,491	2,497		169,007	204	24,083	67,846
	Consumption	20,715		79,221	160,369	22,036		15,000	4,184	218,968	215,108

(*a*) From *Statistisches Jahrbuch des K. K. Ackerbau Ministerium* and *Magyar Statisztikai Evkönyv.*

(*b*) Production from *Statistiques des Mines, Minières, Carrières, et Usines Métallurgiques.* Imports and exports from *Annuaire Statistique de la Belgique.*

(*c*) From *Statistique de l'Industrie Minérale.*

(*d*) Production, imports, and exports from *Statistisches Jahrbuch für das Deutsche Reich.*

(*e*) From *Rivista del Servizio Minerario.*

(*f*) From *Sbornik Statisticheskikh Svedenie o Gornozavodskoi Promyshlennostie Rossie v zavodskom Godu,* St. Petersburg.

(*g*) From the *Reports of the Comision Ejecutiva de Estadistica Minera.* Imports and exports from the *Revista Minera de Espana.*

(*h*) From *British Statistical Abstracts* and from figures furnished by the *Direction Générale des Douanes Fédérales,* Berne.

(*i*) Production from statistics of the Metallurgischegesellschaft, Frankfort-on-the-Main. Imports and exports from Board of Trade returns.

(*j*) The statistics of production are those collected by THE MINERAL INDUSTRY; those of imports and exports are from the reports of the Bureau of Statistics, Washington.

addition there were also treated 1,893 tons of copper ore yielding 706 tons of matte which contained 296 tons of copper, 13,097 oz. silver and 952 oz. gold. The Heberlein-Huntingdon roasting process* will be introduced at Cockle Creek in 1901 and a new type of magnetic separator will be installed.

Canada.—The production of lead in Canada in 1900 was 31,679 short tons, as against 10,931 short tons in 1899. This increase was due mainly to the development of mines in the Fort Steele division, B. C. The Hall Mines, Ltd., was reconstructed in April, 1900, and under the name of the Hall Mining & Smelting Co., Ltd., new capital to the extent of £325,000 in £1 shares was called for, of which 50,000 shares were held in reserve. Prospecting work in the Silver King mine was continued, and the smelting plant was renovated, thereby increasing its capacity to 200 tons daily.

Germany.—The production of lead in Upper Silesia in 1900 amounted to 24,925 metric tons. This province also produced 2,027 metric tons of litharge. Statistics for the entire country are not available at the time of publication.

Italy.—The production of lead in Italy in 1899 was 20,543 metric tons, of which 18,195 tons were produced by the Pertusola smelter. An English company is now operating on the old Roman mines between San Vincenzo and Campiglia. The ore assays 10% Pb and 10% Zn, the latter being in the form of blende.

Mexico.—The production of lead in ores and bullion in Mexico in 1900 was 90,612 metric tons, against 84,656 in 1899, about 90% of the production each year being exported to the United States. The Compañia Minera de Peñoles, of Mapimi, Durango, reports an increased production during 1900, and shipped about one-third of its bullion to the United States for refining, the balance going to Europe. A company has been organized with a capital of $2,000,000 to erect and operate a large smelter near Torréon at the junction of the Mexican Central and the Mexican International Railroads.

In an article on the "Development of Silver Smelting in Mexico," by Otto H. Hahn,† the following figures of smelting costs by the Guggenheim Smelter at Monterey, Mexico, are given: Cost of smelting per ton, roasting included: Coke, $2·50; coal and wood, $0·35; charcoal, $0·01; limestone, $0·05; labor, $1·28; tools and supplies, $0·20; repairs, $0·30; ore sacks, $0·09; federal extraction tax, $0·70; bullion excess tax, $0·16; bullion taxes, $0·12; stamp taxes, $0·10; general expenses, $0·63; general agency expenses, $0·11; New York office, $0·21; interest, $0·02; insurance, $0·03; total, $6·86 Mexican currency; New York exchange rate, $1·8966. These results were obtained from the smelting of 183,230 short tons, dry weight of ore, the average assay of which yielded silver, 37·04 oz.; gold, 0·14 oz.; lead, 13·98%.

Spain.—The production of lead in Spain in 1900, according to the advance report of the *Revista Minera,* was 171,590 metric tons, of which 153,937 were exported in pigs, bars, etc., 544 in manufactures, 3,109 in ores and the balance, 14,000, was consumed in Spain. The quantity of lead ore mined was 334,000 tons. Of the lead exported 71,492 tons were argentiferous and 82,445 tons were soft. The most important lead mines of Spain are situated in the districts of

* THE MINERAL INDUSTRY Vol. VIII., pp. 399–406.
† A paper read before the Institute of Mining and Metallurgy, London, Feb. 21, 1900.

Jaen, Cordova, Ciudad-Real, Badajos and Murcia. In the latter province there are at present 24 lead smelting works, the two most important of which are the Compagnie Française des Mines et Usines d'Esconbrera-Bleiberg and the Compagnie Metallurgique de Mazarron. Most of the lead is exported in crude state, but a part is desilverized at Carthagena and at Linares.*

The Lead Markets in 1900.

New York.—During the year 1900 the lead market has been remarkably steady. The refining interests of the country, which, in 1899, were centered in a few strong hands, have exercised their influence toward the maintenance of a stable value for pig lead. At the close of the year it appears that a further consolidation of refining interests has been consummated, and this is expected to give a steadiness to the lead market which it never could have attained while there were so many conflicting interests. The endeavor has been toward the maintenance of a price which would be satisfactory both to the miner and the consumer. Manufacturers have found that a steady market, even at a high price, is better for them than a fluctuating one. In the former case they can adjust their business to the price, and profits are assured; in the latter, profit depends upon favorable purchases, which must be to a large extent speculative. Consumption throughout the year has been very good. Production has somewhat increased, especially in Missouri. No lead smelted from bullion has been retained here, as throughout the year it has been more profitable to ship it abroad.

The year opened with lead selling at 4·70c. at New York, which price continued to rule during the winter months. In the spring the market declined under pressure from the American Smelting & Refining Co., and in May lead sold at 4c., while in June it sold down to 3·75c. New York. At the end of the month, however, prices reacted to 4·25c. In July the market fluctuated between 4·125 to 4c., and in August it advanced again to 4·25c. In September it rose to 4·375c., which price ruled until the end of the year. It will be observed that, as pointed out above, the fluctuations have been very slight. The average price for lead for New York is 4·73c., 1900, as compared with 4·47c. for 1899.

AVERAGE MONTHLY PRICES OF LEAD IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1896	3·08	3·19	3·14	3·07	3·03	3·03	2·96	2·73	2·77	2·80	4·35	3·04	2·98
1897	3·04	3·28	3·41	3·32	3·26	3·33	3·72	3·84	4·30	4·00	2·96	3·70	3·58
1898	3·65	3·71	3·72	3·63	3·64	3·82	3·95	4·00	3·99	3·78	3·76	3·76	3·78
1899	4·18	4·49	4·37	4·31	4·44	4·43	4·52	4·57	4·58	4·58	3·70	4·64	4·47
1900	4·68	4·68	4·68	4·68	4·18	3·90	4·03	4·25	4·35	4·35	4·58	4·35	4·37

London.—The new year opened with rather better inquiry and with foreign lead quoted at £16 12s. 6d. to £16 15s., English at 2s. 6d. more; but owing to the heavy arrivals in London, values declined to about £16 for foreign. The demand, however, from consumers was good and before the month was out it had recovered about 5s. from the bottom. February opened with values again

* M. P. Jannettaz "Note sur la Metallurgie du Plomb dans la Province de Murcie," *Mem. et Com. Ren. Soc. Ing. Civ. de France*, June, 1900.

up to £16 12s. 6d., and on account of the scarcity of supplies and the fact that producers were well sold, prices remained steady around about this figure. During March business was rather slow, but quotations were steady around about £16 12s. 6d. for foreign and £16 15s. for English. April saw a somewhat better demand and the market became firmer, advancing to £17 for good soft foreign eventually closing at about £16 16s. 3d. May opened with a slight setback in prices, but this brought forth a good demand and there was a rise to £17, and values remained at about this level throughout the month. During June the market was firm, owing to short supplies of available material, and this was accentuated by the strike in the London docks, and prices of near delivery were forced up to £17 5s. Values of lead in America improved and strong reports coming from that side, coupled with a large demand from Germany and Russia, caused an advance during July to £17 12s. 6d. for soft foreign. In August the demand was active all around. Owing to the arrival of some large parcels in London the price of spot metal was brought down to the level of forward stuff, and this caused a setback to about £17 7s. 6d. for foreign and £17 10s. for English. The month, however, closed with values at about 2s. 6d. advance. September again found this article in good demand, and prices rose to about £18 for foreign and £18 2s. 6d. for English. October found consumers somewhat less inclined to operate and values declined to £17 7s. 6d. for foreign and £17 12s. 6d. for English, closing at about these rates. November opened with users showing very little inclination to buy, being well covered for their requirements out of the large arrivals during the previous month, and this caused values to gradually drift away to about £16 15s. The fall in price seemed to drive all consumers out of the market, and during the early part of the month of December the article became quite neglected. Prices at one moment dropped as low as £16 for foreign and £16 2s. 6d. for English lead, but rallied toward the end of the month, the closing quotations being £16 3s. 9d. to £16 5s. for Spanish lead, £16 6s. 3d. to £16 7s. 6d. for English lead.

White Lead, Red Lead, Litharge and Orange Mineral.

PRODUCTION OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1897.....	7,798	$744,709	105,804	$9,522,360	8,591	$773,190	477	$76,320
1898.....	9,160	916,000	93,172	9,391,738	7,460	710,192	653	88,937
1899.....	10,199	1,070,895	103,466	10,812,197	10,020	1,032,060	928	139,200
1900.....	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650

The consumption of white lead in the year 1900 was disappointing in volume and aggregated about 12% less than in 1899. All building operations were restricted by the high price of materials in the first half of the year, and the high cost of linseed oil affected the consumption for repainting. A normal business was done in the fall months, and the shrinkage may be said to have been confined to the spring trade. Territorially this loss was well distributed

over the country east of the Mississippi River, while west of it the trade held well up to normal.

UNITED STATES: IMPORTS OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1896.....	1,543,262	$47,450	1,183,538	$52,409	51,050	$1,615	1,359,651	$51,027
1897.....	1,336,070	46,992	1,101,829	48,988	60,984	1,931	1,486,042	67,549
1898.....	682,449	25,780	506,739	24,334	56,417	2,021	795,116	37,745
1899.....	1,021,573	43,812	584,409	30,211	55,127	3 614	1,141,387	58,242
1900.....	549,551	25,532	456,872	28,366	77,314	2,852	1,068,793	61,885

The Manufacture of White Lead.

By Parker C. McIlhiney.

Although the manufacture of white lead has been the subject of careful investigation for many years and much thought and labor have been bestowed upon it by competent men, the old-fashioned Dutch process by which the bulk of it has been manufactured in times past still maintains its position as the most important process of manufacture. The process labors under a number of disadvantages on account of the primitive method of bringing together the essential constituents, lead, carbonic acid and water. The spent tan bark used to furnish carbonic acid and heat is the occasion of undesirable dirt requiring subsequent mechanical treatment for its removal. The progress of the operation receives little direction after the materials have once been assembled into a corroding house and there is consequently a degree of irregularity in composition not necessarily impairing its pigment value. Although the Dutch process would appear to be very susceptible of variation in composition of product, actual analyses of such commerical white leads disclose little variation from uniformity. Notwithstanding all this, there is some feature of the conversion of metallic lead in this crude way, whether it be the slow progress of the transformation, the order in which the materials act upon one another, or the intermediate production of the proper lead compound between metallic lead and white lead, that the numerous inventors who have attempted to conduct the process of corrosion quickly and by the use of the same essential ingredients have found it very difficult to imitate. The products of many of the quick processes are slightly crystalline in character and consequently less opaque than the amorphous and opaque Dutch lead when of first quality. As white lead is primarily valuable for its opacity or covering power this defect is fatal.

The processes of manufacturing white lead may be classified as follows:

I. Processes in which metallic lead, acetic acid, water, and carbonic acid are brought together all at once.

A. Those in which the lead remains at rest and the white lead forms a layer of increasing thickness upon it.

1. Dutch. 2. German Chamber. 3. Bailey.

B. Those in which the white lead is mechanically removed from the surface of the metallic lead as fast as it forms. 1. Carter.

II. Processes in which the metallic lead is first converted into basic acetate by the action of air, water, and acetic acid or acetate of lead and this solution carbonated by a separate operation.

1. Brandram Brothers' Process (English B. B. Lead). 2. Matheson Process (E. W. Dahl).

III. Processes in which lead oxide or lead hydroxide made by wet corrosion of metallic lead is converted into white lead by carbonic acid and water alone.

1. Bunn. 2. Coleman.

IV. Processes in which lead oxide made by the dry process is treated with acetic acid, or lead acetate, and water and carbonic acid at the same time.

1. Kremnitz. 2. Bischof, first reduces the lead oxides to protoxide. 3. English. 4. Orr & James.

V. Processes in which litharge made in the dry way is dissolved in acetic acid or lead acetate and carbonated by a separate operation.

1. Thénard, Clichy, French. 2. Mathews, uses liquid containing 7 to 7·5% glycerine. 3. Waller-Sniffen.

VI. Miscellaneous precipitation processes.

1. Steinhardt & Vogel. Lead nitrate solution with 20% excess of sodium carbonate mixed boiling. 2. Condy's process. Acetate of lead solution sp. gr. 1·04, mixed with slight excess of sodium bicarbonate. 3. "Flake white process." Acetate of lead solution precipitated with carbonate of soda. 4. Dale & Milner Process. Basic chloride of lead made by the action of common salt and water upon litharge is converted into basic carbonate by carbonic acid.

VII. Electrolytic Processes.

1. Luckow. 2. Tibbits. 3. Brown. 4. Woltereck.

VIII. So-called white lead processes which give compounds other than the basic carbonate.

1. Lewis & Bartlett Bag Process. 2. Freeman Process. Acetate of lead precipitated with sulphuric acid giving lead sulphate.

There has been no change in the modern American method of operating the Dutch process as described in THE MINERAL INDUSTRY, Vol. VII., p. 447.

The chamber process is essentially the same as the Dutch process except that no tan bark is used, the necessary carbonic acid being supplied by burning charcoal. An objection urged against it is that it requires constant attention during the whole period of the corrosion, whereas, in the Dutch process comparatively little attention is necessary until the stack is to be taken down. In one instance of its use a stack which formed part of a Dutch process plant was filled as usual with pots, acetic acid and buckles omitting only the tan bark, the carbonic acid being supplied from a charcoal furnace. In this case the corrosion was complete in one month, and the entire product was hard, pure white material.

The Bailey process is a variety of the chamber process in which the metallic lead is first melted in a cast-iron pot, then run into an auxiliary pot in which the temperature is kept just above the melting point; from this it is run through a nozzle having from 150 to 200 holes 0·009 to 0·010 in. in diameter. The lead,

which cools and solidifies into fine filaments immediately on reaching the air, is spread upon lead trays 5×3 ft.×5 in. deep. The filled trays are dipped into 8% acetic acid for a moment and then piled one above the other in stacks. Carbonic acid is caused to enter the stacks until the process is ended, which requires three days.

In Carter's process, which in commercial importance in the United States is next to the Dutch process, metallic lead in a granulated form is moistened with acetic acid and treated in revolving barrels with carbonic acid. The English "BB." lead and that made in the United States by W. J. Matheson & Co. are made by practically the same process.

The Bunn process uses no acid. The molten metallic lead is poured into water through a sieve by which operation it is broken up into small pieces which are finely comminuted by a machine designed especially for the purpose. The product remains in suspension in water on account of its extreme fineness. It is oxidized by air under pressure and the resulting oxide or hydroxide is treated directly with carbonic acid under pressure which converts it into white lead.

The Coleman process is almost identical with the Bunn process except that the metallic lead is not so finely divided and the treatment with air and carbonic acid is made in a revolving barrel.

The Kremnitz process uses litharge which is mixed with a solution of lead acetate or of acetic acid to form a consistent paste which is spread out on tables placed one above the other in rooms to which carbonic acid is admitted. The paste is stirred occasionally, and litharge is added from time to time until the acetate present is reduced to the minimum for fairly rapid conversion. When the litharge is all converted to white lead the paste is dried, and then ground in water. The English process is substantially the same as the Kremnitz. Litharge is mixed with about 1% of its weight of lead acetate in solution and treated with carbonic acid in a series of troughs.

The Bischof process is designed to obviate the difficulty which occurs in the Kremnitz and other processes of that type on account of the presence of lead oxides more highly oxidized than PbO in the litharge. The PbO being easily converted, Bischof first treats the litharge at a temperature of 250 to 300°C. with a reducing gas (as water gas) in a revolving cylinder. The product which is lead protoxide is converted into hydrate by moistening with water and exposure to the air. This is then made to a paste with acetic acid or lead acetate and exposed to the action of carbonic acid in revolving cylinders being thereby converted into white lead. Bischof also mixes sugar or its equivalent with the paste.

In the Orr & James process litharge is ground under water to an impalpable powder, floated in water to settling tanks, where it is settled and then treated with dilute acetic acid and carbonic acid. After about 2·5 hours of this treatment, it is neutralized with sodium carbonate, washed, pressed, dried and ground.

The French or Clichy process, invented by Thénard and put into operation by Rouard, is the best example of its class. Litharge made by oxidizing metallic lead in a reverberatory furnace is boiled with a neutral solution of lead acetate whereby it is dissolved and converted into lead subacetate. This solution is cooled and settled and when clear is drawn off into other vessels. Carbonic

acid in small streams is passed through the solution and precipitates the white lead which is filtered out, washed and dried. In the Matthews process the litharge is dissolved in a solution of lead acetate containing about 7% of glycerine, the solution being effected in a rotary digester. The liquid is then filtered out and treated with purified carbonic acid gas in tall wooden tanks. The precipitated white lead is separated by filter presses, the mother liquor being used over again. The loss of glycerine in the wash water is said to be small.

The Waller-Sniffen process is also of this class. Its novelty is that the precipitation of the white lead by carbonic acid is effected under pressure. Not only is litharge treated in this process, but also cerussite, the lead carbonate ore. Cerussite, reduced to a state of suitable fineness, is boiled with the solution of lead acetate forming a solution of basic acetate, and liberating carbonic acid, which is stored in a gasholder for use later on in precipitating white lead.

In the electrolytic processes there are usually two chemicals involved, one of which, when electrolyzed, liberates at a lead anode a radical which on uniting with lead furnishes a soluble salt of lead; the other by double decomposition with the soluble salt gives a lead carbonate, hydroxide, or basic carbonate.

In the Luckow process the chemical of the first class is sodium chlorate and that of the second class sodium carbonate, the two being in the proportions of 80 of chlorate to 20 of carbonate. Luckow claims to have discovered that the purest products are obtained in processes of this type when the electrolyte is so diluted that it is dissociated to as great an extent as is compatible with economical conductivity. He uses a 1·5% solution of the mixed salts and keeps the solution slightly alkaline. Carbonic acid is passed into the solution as fast as precipitation of white lead removes it. The Tibbits process resembles the Luckow except that stronger solutions are used.

In the Brown process, a lead anode, a copper cathode, with intervening porous partition and a solution of sodium nitrate 1 lb. to the gallon are employed. The passage of the current results in the formation of caustic soda in the cathode compartment and lead nitrate in the anode compartment. These two solutions are drawn off and mixed, giving lead hydroxide and sodium nitrate. The lead hydroxide is separated by a rotary filtering device the sodium nitrate solution being returned to the electrolytic tanks. The lead hydroxide is then treated with a solution of sodium bicarbonate or carbonate giving caustic soda and lead carbonate of any desired degree of basicity. It is claimed that the caustic soda solution removes a number of impurities from the lead. The inventor claims also that when made by this process the carbonate is as good as the basic carbonate.

In the Woltereck process, a 10 to 15% solution of a mixture of ammonium acetate or nitrate and bicarbonate is electrolyzed and carbonic acid gas passed continuously into it, resulting in the production of a precipitate of white lead which is continuously withdrawn. It is found necessary to provide for a good circulation of the electrolyte.

The Lewis & Bartlett Bag process produces from galena by smelting both metallic lead and a white pigment. The crushed ore is heated, volatilized and condensed. The white lead so obtained is deficient in covering power, but is very permanent in character.

Recent Improvements in Lead Smelting.

By H. O. Hofman.

B. & H. Ztg., Berg- und Hüttenmännische Zeitung; *Ch. Ztg.*, Chemiker Zeitung; *Colo. Sc. Soc.*, Proceedings of the Colorado Scientific Society; *E. & M. J.*, Engineering and Mining Journal; *Eng.*, Engineer; *Eng. News*, Engineering News; *I. T. R.*, Iron Trade Review; *M. I.*, The Mineral Industry; *M. & M.*, Mines and Minerals; *M. & S. P.*, Mining and Scientific Press; *Mod. Mach.*, Modern Machinery; *O. J.*, Berg- und Hüttenmännisches Jahrbuch der K. K. Bergakademien; *O. Z.*, Oesterreichische Zeitschrift für Berg- und Hüttenwesen; *S. M. Q.*, Columbia School of Mines Quarterly; *Trans. A. I. M. E.*, Transactions American Institute of Mining Engineers; *Trans. Inst. Min. & Met.*, Transactions Institute of Mining and Metallurgy; *Trans. North Engl. Inst. Min. & Mech. Eng.*, Transactions North of England Institute of Mining and Mechanical Engineers; *Z. E. Ch.*, Zeitschrift für Electrochemie.

INTRODUCTORY.

New Publications.—H. F. Collins has written a treatise on "The Metallurgy of Lead and Silver," London, 1899, Griffin & Co. Part I. ($5.00). It deals with the metallurgy of lead and the desilverization of base bullion. It aims to give a concise description of the present practice of silver-lead smelting in the leading districts of the world and does it in a most satisfactory manner. The book is one of the series of treatises edited by Sir W. C. Roberts-Austin.

Corrosion of Lead Service-Pipes by Water.—Clark* investigated the action of 800 samples of water upon the lead service-pipes of 63 towns and cities in Massachusetts. The largest amount of lead found in any sample of water was 8·5460 parts in 100,000, the smallest 0·0023. The analyses indicate that surface waters having the largest amount of solids and the greatest degree of hardness take the least lead from the pipes, and that the same is the case with ground waters having the greatest amount of solids and being the hardest. Experiments showed that oxygen and carbon dioxide were the two active agents in the water. The report discusses also the effects of waters upon tinned and galvanized pipes.

Sampling.—The firm of Fried. Krupp, Grusonwerk, Magdeburg-Buckau, Germany† (New York City, 15 Gold Street), has brought out the Geissler automatic sampling machine represented in Figs. 1, 2, and 3. Fig. 1 is a vertical cross-section through the center, Fig. 2 a vertical longitudinal half-section, and Fig. 3 a half front elevation. The machine consists essentially of four revolving horizontal cylinders, each having a slot which cuts out with every revolution as sample the entire falling stream of ore. The ore, fed through the hopper at the top strikes the upper cylinder which is the largest of the four and makes 12 revolutions per minute. The slot takes out the sample and delivers it on top of the second cylinder (which is smaller than the first and makes 6 revolutions per minute), while the rejected ore drops into the chute at the left (Fig. 1). The second cylinder cuts down the first sample and delivers it to the third cylinder (3 revolutions per minutes) while the rejected ore again passes into the same chute. The third and the bottom (or fourth) cylinder each reduce the previous sample. The power is applied to the shaft of the top cylinder, the other cylinders are operated from this by chains and sprocket-wheels. The machine is made in four sizes, the smallest being run by hand, the other three by power. While the machine is compact and easily cleaned, the cylinders having doors kept tightly closed while sampling, it will be noticed that it cuts down the sample four times

* *Massachusetts Board of Health Report*, 1898, pp. 541–585; *Eng. News*, Jan. 4, 1900, p. 7.

† *Chem. Ztg.*, 1899, No. 19; *O. Z.*, 1900, 107; *B. & H. Ztg.*, 1900, 321, 333; *E. & M. J.*, Jan. 27, 1900.

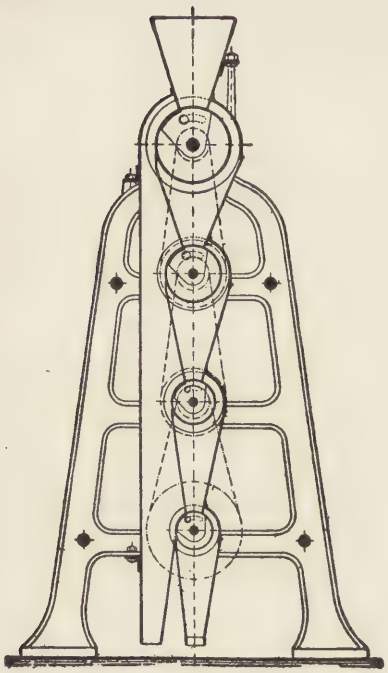


FIG. 1.—Vertical Cross Section through center.

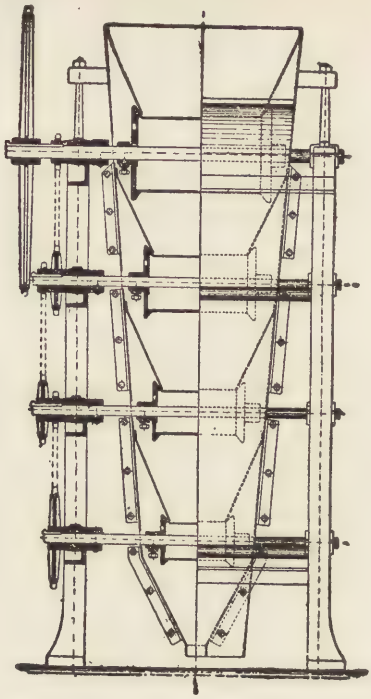


FIG. 2.—Vertical Longitudinal Half Section.

FIG. 3.—Half Front Elevation.

THE GEISSLER AUTOMATIC SAMPLING MACHINE.

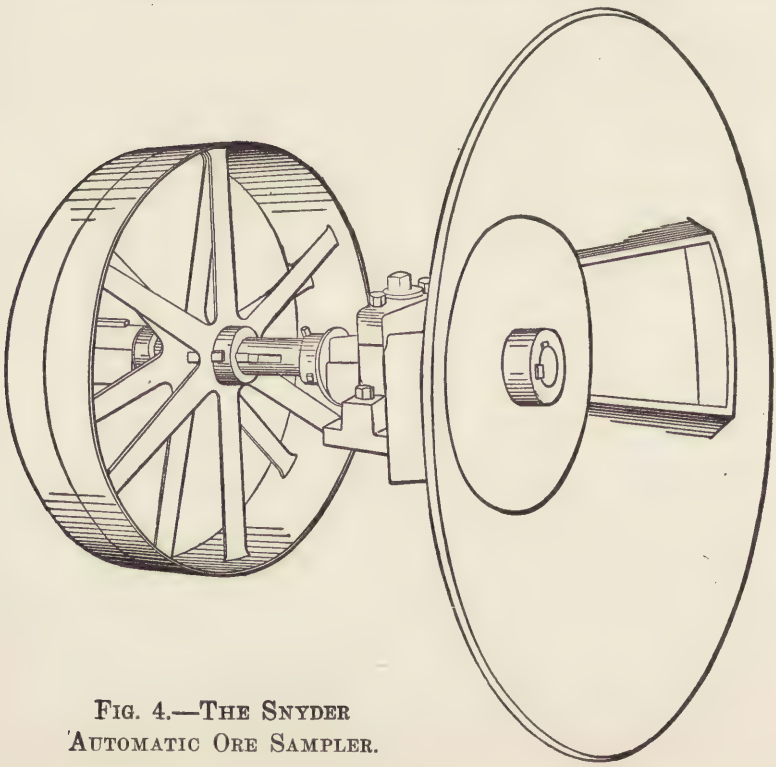


FIG. 4.—THE SNYDER AUTOMATIC ORE SAMPLER.

without recrushing which makes it suited only for finely divided ores in which the values are pretty uniformly distributed.

An editorial* reviews the different methods and machines for sampling ores. The only new apparatus described is that of Geissler which has just been discussed.

The Gates Iron Works, Chicago, Ill., have put on the market the Snyder automatic ore sampler.† (Fig. 4.) It consists of a flat dish-shaped casting, similar to a miner's gold pan, mounted with the bottom on a horizontal shaft having a tight and loose pulley. The disk has a sector-like opening which with every revolution of the machine cuts out the whole of a stream of ore directed against it as a sample and delivers it at the back, while the rejected ore glides down in front and is collected in a separate bin.

Samplers have been patented by Flanders‡ and Damn.§

The Bickford Burners Co., Camborne, Cornwall,‖ describes and illustrates crucible and muffle furnaces heated with oil.

Assaying.—Flath¶ experimented upon the kind and amount of fluxes that should be used in assaying lead ores in iron crucibles, and compared the results obtained in the dry way with those from wet determinations. He first ascertained that with a charge of 25 g. of ore an addition of 60 g. of flux was sufficient to cover the lead.

Number of Assay.	Weight of Ore, in grams.	Weight of Fluxes, in grams.			Yield in Lead, Per cent.	
		Soda.	Borax.	Argols.	Dry Assay.	Wet Assay.
1	Galena, 25	50	45	5	71·4	72·35
2	" 25	70	25	5	71·9	72·35
3	" 25	76	19	5	71·8	72·35
4	" 25	88	7	5	70·2	72·35

The fusion in assay No. 1 was too rapid, assays Nos. 2 and 3 were satisfactory, in assay No. 4 the slag was too viscid. It was believed that it was not necessary

Number of Assay.	Weight of Ore, in grams.	Weight of Fluxes, in grams.			Yield in Lead, Per cent.	
		Soda.	Borax.	Argols.	Dry Assay.	Wet Assay.
5	Galena 25	70	28	2	75·9	76·35
6	" 25	70	30		75·8	76·35
7	" 25	70	26	4	54·5	55·20
8	" 25	70	30		54·5	55·20
9	Lead sulphate..25	70	26	4	57·6	58·02
10	" ..25	70	30		57·7	58·02
11	Litharge 25	70	25	5	88·7	89·28
12	" 25	70	28	2	88·9	89·28
13	" 25	70	30		88·7	98·28

to add any argols to the charge. In order to ascertain the effect of argols the preceding experiments were carried out.

* *B. & H. Ztg.*, 1900, 321, 333.
† *E. & M. J.*, Nov. 10, 1900.
‡ United States Patent No. 649,288, May 8, 1900.
§ United States Patent No. 655,478, Aug. 7, 1900.
‖ *Eng.*, Sept. 28, 1900; *Mod. Mach.*, January, 1901.
¶ *Chem. Ztg.*, 1900, 264; *O. Z.*, 1900, 312.

While the addition of argols is not absolutely necessary to obtain satisfactory results, it is advantageous to use a small amount especially in the presence of carbonate ores. The most suitable general flux proved to be: Calcined soda, 70%; calcined borax, 28%; argols, 2%. With this flux the following dry lead assays were made on substances the accurate values of which had been ascertained by analyses:

Character of Ore.	Galena, lump.	Galena, lump.	Galena concentrate, coarse sand.	Galena concentrate, coarse sand.	Galena concentrate, fine sand.	Galena concentrate, fine sand.	Galena concentrate, fine slime.
Dry Assay.....	67·0	47·2	70·5	46·8	75·4	43·0	24·5
Wet Assay.....	67·45	47·80	71·12	47·65	76·15	43·92	28·20

Character of Ore.	Galena concentrate, fine slime.	Galena and Pyrite.	Pyro-morphite.	Cerussite.	Mine Fines.	Flue-Dust.	Lead slag.
Dry Assay.....	25·42	59·0	71·0	65·1	5·7	59·0	0·5
Wet Assay.....	29·50	59·95	71·40	65·40	6·48	60·48	1·25

With slimes the results from the dry assay were lower than when the ore was less fine. It was found that only two-thirds of the copper contents of an ore entered the lead button, and that most of the antimony was taken up by the lead.

L. Strauss* records some experiments made to find out what influence silica had upon the loss of silver in the scorification assay.

C. Jouët† publishes several schemes for determining in lead and copper slags the following compounds: Silver, lead, silica, iron, manganese, lime, magnesia, zinc oxide, alumina, copper, sulphur, arsenic, antimony, bismuth and alkalies.

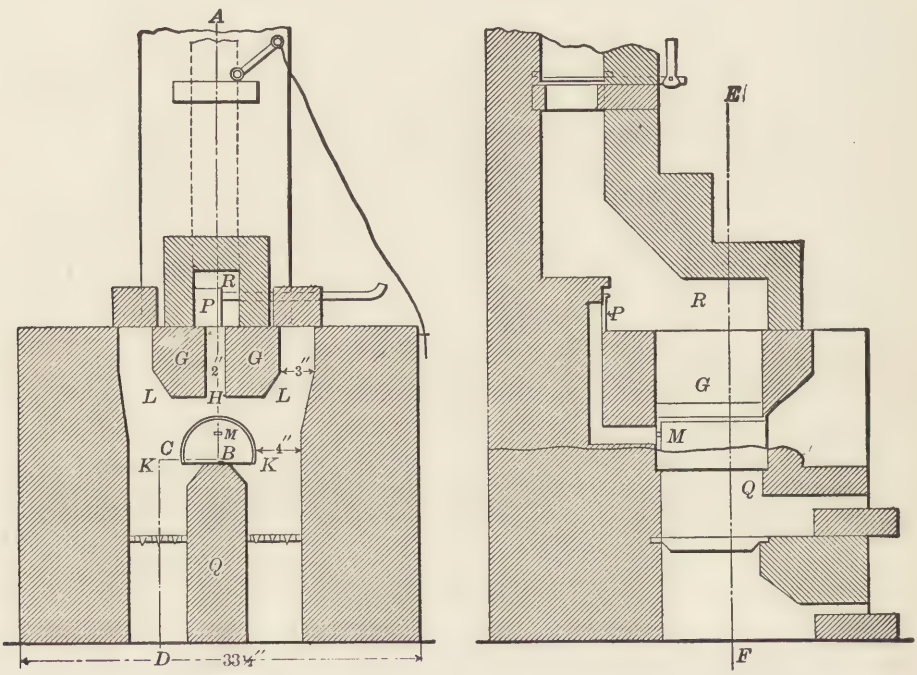
T. Ulke‡ describes the details of manipulation in titrating the lime of slags with potassium permanganate as practiced by F. D. Aller, Perth Amboy, N. J. They are: Dissolve 0·5 g. finely pulverized slag in 30 c.c. hot water and 6 c.c. nitric acid agitating the beaker to prevent the powder from adhering to the bottom, dilute to 150 c.c., add one drop sulphuric acid to precipitate any barium present and boil. While boiling, add ammonia drop by drop, stirring until the neutral point is almost reached. The solution turns deep red, but no iron is precipitated and only flakes of silica fall out. Now add 3 g. ammonium oxalate, cover beaker, boil for a few minutes, filter the precipitated calcium oxolate (which is granular, filters easily and gives a clear filtrate) through a Schleicher & Schüll filter No. 597, wash with hot water, then once with ammonia and twice with hot water, and titrate in the usual way. Time required 15 to 20 minutes.

Mietzschke§ experimented on different methods for determining by assay iridium in precious metal alloys. The following mode of procedure gives satisfactory results: Weigh out four samples of 250 g. each, cupel, brighten hot, inquart, treat two buttons with nitric acid and two with sulphuric acid, re-inquart the combined residues of the four buttons and treat with nitric acid. All the silver and platinum will have been dissolved. The residue contains iridium and

* *Trans. A. I. M. E.*, August, 1900. † *S. M. Q.*, XXII., 64. ‡ *E. & M. J.*, Feb. 10, 1900. § *B. & H. Ztg.*, 1900, 61.

gold. Dissolve this in nitro-hydrochloric acid, precipitate the gold with ferrous sulphate and weigh; the difference gives the iridium. For the direct determination of iridium the following method is recommended: Collect any fine scales of iridium, liable to be floated off in removing the silver-platinum solutions from the gold-iridium residue, on a filter, collect on the same filter the residual iridium from the treatment of the gold-iridium with nitro-hydrochloric acid, burn the filter and add the ash to the filtrate of the precipitated gold, evaporate to dryness, ignite, scorify the residue with lead and cupel having added 300 mg. silver, treat the button with nitric acid; the residue is iridium.

Assay Furnaces.—Martyn* describes and illustrates the coke muffle furnace



Cross Section on *E F.* Longitudinal Section on *A B C D.*

FIG. 5.—COKE MUFFLE FURNACE, DESIGNED BY T. G. MARTYN.

used at the Royal School of Mines, London, which has several valuable new features. In Fig. 5 the muffle *M* is seen to be resting on a brick wall *Q*, beveled at the top, which divides the grate into two equal parts. The open space on either side of the muffle is larger than the feed-openings *L* (4×3 in.) hence no obstructions are caused, even if the fuel clinkers. The single-brick walls *G* inclosing the flue *H*, prevent any fuel from resting on the roof of the muffle. *P* is a sliding damper, *R* a large horizontal flue leading to the stack.

* *Trans. Inst. Min. & Met.*, 1898–99, VII., 331.

SMELTING OF LEAD ORES.

In the Ore-Hearth.—H. F. Bain* describes the present method of working with the Waters ore-hearth. At the works near Dubuque, Ia., there are two of these furnaces. The hearth of a furnace is made of cast iron, 2·5 in. thick, and is not water-cooled; it is 20×26 in. and 14 in. deep. The casting lasts 12 to 14 years and costs about $100. The necessary blast is furnished by a blower driven by an 8-H.P. engine. Smoke and fume issuing from the hearth pass through a horizontal sheet-iron pipe, 3 ft. in diameter and 100 ft. long, ending in a chimney 20 ft. high. The two hearths are run alternately, working 16 and cooling 8 hours. Two men in an 8-hour shift treat 300 lb. ore, burning half a cord of wood; about 72% of the lead is recovered in the form of bars, which weigh 72 lb. each and are marketed in St. Louis and Chicago.

The whole plant can be duplicated for less than $1,000. The gray (first) slag is re-treated in the ore-hearth, furnishing lead and waste (second) slag. The subjoined two analyses cannot well represent averages of the products; they must have been made from grab-samples, and have correspondingly little value.

	H_2O.	Insol.	Fe_2O_3.	Al_2O_3.	P_2O_5.	MnO.	CaO.
First Slag	0·17	4·92	18·47	11·86	1·52	2·49	16·85
Second Slag	0·05	27·68	29·60	7·04	8·78	1·94	15·35

	MgO.	SO_3.	ZnS.	PbS.	Pb & PbO.	FeS.
First Slag	8·61	3·22	4·45	23.37	4·48	
Second Slag	7·71	0·37				9·48

In the Blast Furnace: Roasting Furnaces.—The Zellweger† roasting kiln is a straight-line single-hearth mechanical reverberatory roasting furnace, 15×135 ft., with external fire-places. The new feature is the rolling stirrer which turns over the ore and moves it slowly from feed to discharge. It consists of a heavy shaft carried by wheels, 6 ft. in diameter, rolling on tracks in the depressed wheel-pits on either side of the hearth. The shaft carries a number of collars on which are mounted projecting V-shaped blades. While traveling from feed to discharge, the collars are locked to the shaft, and the blades scoop up the ore during one-half of a revolution and discharge it during the other half, thus stirring, mixing and moving it. During the return trip the collars unlock, and revolving around the shaft cause the blades to displace the ore only about in the same way that a plow or rake would. The furnace is in use at the works of the Cherokee Lanyon Spelter Co., Gas City, Kan., and treats in 24 hours 15 tons of blende, reducing the sulphur to 1%, or 12·5 tons to 0·5% S, or 16·5 tons to 1·5% S.

Blackmore‡ describes and illustrates the Godfrey mechanical roasting furnace. It resembles in a general way the Brunton mechanical roaster, consisting of an annular rotating horizontal hearth with stationary rake which plows over the ore or discharges it when the blades are set for that purpose. Beside some minor

* *M. & M.*, 1900, XX., p. 477. † *E. & M. J.*, March 3, 1900. ‡ *Trans. Inst. Min. & Met.*, 1898-99, VII., 323.

mechanical details, the Godfrey furnace differs from that of Brunton in that the stationary rake is placed in the open, the roof covering the entire hearth with the exception of a sector reserved for the rake. The ore, when charged through the roof or through a side-door, quickly becomes evenly distributed over the hearth and uniformly heated. With every revolution of the hearth, the ore passes through the open sectoral space and comes in contact with pure air, undiluted by products of combustion from the fire-place or by roasting gases.

The furnace is 20 ft. in diameter; the sectoral space is 3·5 ft. wide on the periphery and tapers to 2 ft. near the center; the hearth makes one revolution in from 2 to 3 minutes and being supported by ball-bearings only 1 H.P. is necessary for the mechanical work. The weight of the iron work of the furnace is 25 tons; there are required 7,000 red brick and 8,000 fire brick.

The furnace will roast in 24 hours 5 tons blende, reducing the sulphur to 2%, or 10 tons leady zinc ore, reducing the sulphur to 10%, or 15 to 20 tons cupriferous pyrite.

The Edwards* mechanical ore-roasting furnace, in use at Ballarat and Bendigo, Victoria, Australia, for the dead-roasting of gold-mill concentrates, contains many new features. It is a single-hearth furnace with fire-place at one end. Instead of standing on the floor, the furnace, enclosed by girders, is supported by a horizontal shaft in the center and so balanced that it can be easily raised or lowered by an elevation gear attached at one end. In this manner the speed with which it travels through the furnace can be retarded or accelerated. The stirring mechanism consists of vertical revolving shafts (with horizontal arms) passing through the roof. They are driven by gearing actuated by shafts which are supported by frames attached to the girders. The horizontal arm of one stirrer travels in a direction opposite to that of its neighbor, and the vertical shafts are placed sufficiently close that the horizontal arms may cut each other's circles. The ore thus takes a zigzag course in its passage from feed to discharge. Shafts and arms in the cool part of the furnace are solid, in the hot part they are hollow and water-cooled; in the cool part the arms make four revolutions per minute, in the hot part one.

Meech† and Wedge‡ patented furnaces similar in principle to those of McDougal or Herreshoff. Furnaces resembling that of Brückner have been patented by Stewart§ and Teller.‖ Johnson¶ patented an oblong mechanical multiple hearth furnace and finally Argall** a roasting furnace, with a bottom extending beyond the roof and having a reciprocating motion, and with stationary rakes which are raised out of the ore with every return movement of the hearth and lowered into it with every forward movement.

Cost of Roasting.—Iles†† gives some data on the cost of roasting at the works of the Globe Smelting and Refining Co., Denver, Colo., for the years 1887-1898.

* *E. & M. J.*, July 21, 1900.
† United States Patent Nos. 641,640, 641,641, Jan. 16, 1900, and No. 652,193, June 19, 1900.
‡ United States Patent No. 648,183, April 24, 1900, and No. 654,335, July 24, 1900.
§ United States Patent No. 645,761, March 20, 1900.
‖ United States Patent No. 649,999, May 20, 1900.
¶ United States Patent No. 642,334, Jan. 30, 1900.
** United States Patent No. 653,202, July 10, 1900.
†† *E. & M. J.*, Aug. 18, 1900.

In the long-hearth hand reverberatory furnace the cost of roasting was reduced from $3·975 per ton in 1887 to $2·620 in 1898. The decrease was due (1) to an increase of 2 ft. in the width of the furnaces which allowed making the ore-charge 200 lb. heavier and, with six charges in a furnace, increased the capacity for 24 hours by 1,200 lb.; (2) to a change in the mode of working, in that the fuse-box was thrown out and the slagging of the roasted ore stopped. In 1898 the cost of roasting a ton of ore in the hand reverberatory furnace was: labor, $1·50; coal, $0·48; general expense, $0·77; total, $2·75; in the two Brown-O'Hara mechanical roasters of the works it was: labor, $0·76; coal, $0·62; general expense, $0·83; total, $2·21. Although the figures show $0·54 per ton of ore in favor of the mechanical furnace, they are not to be preferred to the hand-roasters, as according to the author, the apparent advantages are more than offset by the expenses for repairs not included in the above statements of cost.

The Blast Furnace.—Messiter* has constructed a furnace tapping hood by means of which all the fumes that arise in tapping are drawn off through the natural draught of a vertical sheet-iron pipe 24 in. in diameter and 35 or 40 ft. long. The hood is an approximately cubical sheet-iron box, resting on an angle-iron frame, the sides of which are closed with pieces of sheet-iron provided with handles, while at the front are two short swinging doors leaving a 1-in. slot between them so as to watch the filling of the slag-pot. The hood is open at the bottom; at the top it is contracted to a nipple, over which is wired a canvas bag to connect it with the draught-pipe; at the back it is extended to meet the water-jacket near the tap-hole, while at the front a truncated pyramid, pointing toward the tap-hole, reaches nearly to the back of the hood. It will be seen that the hood is constructed so as to draw off as little as possible of the surrounding air, and experience has proved this to be a correct principle.

Hahn,† under the heading "On the Development of Silver Smelting in Mexico," discusses the work of Smelter No. 3 of M. Guggenheim's Sons at Monterey, Mexico, which has many points of general interest.

Low-grade ores are divided into 100-ton lots. Ores of the same class are bedded; thus, iron-ore beds hold about 2,000 tons; beds of lead ores, 800 to 1,000 tons; silver ores form smaller beds.

Hand-sampling by fractional selection and quartering is the method in common use. The assay-samples are ground to pass a 120-mesh sieve. From coke, moisture and assay samples are taken only occasionally. Coke is analyzed for fixed carbon and volatile matter, beside ash, some metallurgists condemning coke when it contains over 2% volatile matter. Limestone is sampled and analyzed occasionally, when a change in the quality is suspected or a new kind received. Iron ores not containing lead or silver are used only in blowing in. The matte is weighed and sampled while it is being crushed for the roasting furnaces and after it has been roasted. It is designated by the name of the month in which it is produced, for the monthly cut-off or taking of inventory. Speise is weighed as produced, but sampled and assayed only when a sufficiently large amount has accumulated. The sample-mill is 89×149 ft., contains two

* *E. & M. J.*, March 17, 1900.

† *Trans. Inst. Min. & Met.*, Feb. 21, 1900; *M. & S. P.*, July 28, Aug. 4, 11, 18, 25, Sept. 1, 8, 1900.

7×10 in. crushers, two pairs of rolls, 10×16 in. and 10×20 in.; the sulphide-mill has one 7×10 in. crusher, one pair 14×30 in. rolls and two cup elevators, one of which delivers the crushed ore to the rolls, while the other conveys the crushed ore to a storage bin. Matte is pulverized in a ball-mill with 120 steel balls; it will reduce in 10 hours to a size suitable for roasting from 80 to 100 tons weathered first matte, but only 10 tons of 30% copper matte. Speise cannot be pulverized in a ball-mill, the broken pieces being simply rounded off. The sampling and sulphide mills handle about 800 tons ore per day of 10 hours.

In purchasing ores, the works make their offers f. o. b. the railroad station nearest the mines, as they obtain better rates than can miners and ore-brokers. Appended is the schedule for 1898: "Pay for all the silver contained, $36·50 a kg. Pay for all the gold contained, if not less than 3·43 g. per 1,000 kg. (0·1 oz. per ton), 62·5c. United States currency per g. Pay for 90% of the lead, not under 5%, 5·5 centavos per kg. Add for excess of iron or manganese over silica 15 centavos per unit. Deduct 20 centavos for each unit of silica in excess of iron content. Deduct 30 centavos for each per cent. of sulphur over 3%, the maximum charge being $4·50 per metric ton of ore. Deduct 55 centavos a unit for zinc, if over 8%. Deduct 55 centavos for each per cent. of arsenic, antimony or baryta over 3%, all three added together.

FREIGHT AND TREATMENT CHARGES PER TON OF ORE.

Amount in dollars	20	18	14	12	10	7	4½	2½	½
With per cent. lead	5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–55

PREMIUMS PER TON OF ORE.

Amount in dollars	1·5	3·5	5·5
With per cent. lead	45–50	50–55	55–60

"The stamp tax has to be paid by the vendor of the ore; the federal tax of 3% on the gold and silver value as well as the mint tax of 2% on the gold are paid by the ore purchasers." Large producers, especially when entering into long-time contracts, obtain more favorable rates.

All ores containing over 8% S are roasted unless they run very high in silver, when they are spread over a bed of clayey ore running low in sulphur. Quartzose ores allowing the silver ore to sift through are not well suited for this purpose. There are six long-hearth hand reverberatory roasting furnaces without fuse-boxes. They are heated with gas furnished by six Taylor gas-producers, 7 ft. in diameter and 16 ft. high. These have a sufficient capacity for twelve roasting furnaces, but it is advisable not to force the producers and to have two in reserve. The roasters treat 72 tons matte (23% and 16 to 18% S) or 63 tons ore in 24 hours at a total cost of $2·43 and $2·73 per ton, of which 30c. is for power for electric elevators, electric light, tools, repairs, etc.

The smelting department contains ten blast-furnaces, 42×120 in. and 42×102 in. at the tuyeres, and 13 ft. 10 in. and 14 ft. 1 in. high. The furnaces are 25 ft. apart from center—a distance too small. The crucible, 27 to 30 in. deep, has tapering sides, the taper at front and sides being steeper than at the back. The

crucible rests on a wrought-iron plate having the form of an elongated octagon. The plate has a rim of angle-iron riveted to it. The sides, 3 ft. 6 in. high, consist of eight heavy cast-iron plates bolted together through lugs and strengthened by binders 2·5 in. square. Between brick wall and iron casing is a 3-in. space tamped with sand or a mixture of sand and clay. The lead well is located between two tuyeres toward the front at one-third the distance between front and back plate. It is not bolted onto the side plate, but forms part of it. The channel of the siphon tap is 6 in. square and curved. The author condemns the practice of making the channel oblong with the long sides upright, as there is danger of matte entering the channel and clogging it. The water-jackets are of cast iron, six on a side and two at front and back; the water-space is 6 in. wide, the wall 0·625 in. thick. The tuyeres (12 in number) in the centers of the jackets are 11 in. above the top of the crucible with the large, and 13 in. with the small furnaces; they are conical, the inner diameter is 3·75 in., the outer 4·625 in. The center of the projection for inflow and outflow of cooling water is 4 in. above the top of the jacket. With the large furnaces (42×120 in.) the side-jackets are 41 in. high, 20 in. wide and have a bosh of 6 in. (74·5°); with the small furnaces (42×102 in.) they are 54 in. high, 17 in. wide and have a bosh of 9 in. (73·5°). The author believes that a flatter bosh than this is a mistake. The front and back jackets are 27 and 34 in. wide at the bottom and 37 in. wide at the top. They have the same amount of bosh as the side-jackets and are fastened to the side-jackets by wedge-bolts passing through lugs. With a high-pressure blast extra binders are placed around the jackets. The front jackets are 10 in. shorter than the back jackets to admit the tapping-jacket of cast iron (better of bronze); this is 26 in. long, 14 in. high and has a 3·5 in. water-space; the conical tap-hole is 2·5 and 5 in. in diameter. The four hollow cast-iron columns carrying the shaft, each weigh about 800 lb. The author condemns the older methods of supporting the shaft (by means of carrier-plates or I-beams) and advocates the method first put into practice at the Germania Lead Works, Salt Lake City, Utah,* where heavy brick arches are sprung between skewbacks fastened to the tops of the columns, the thrust being taken up by tension rods having threaded ends. The shaft, 9 in. fire brick and 18 in. red brick (which is too thin), is carried 6 to 7 ft. above the charging doors, leaving spaces for two feed-doors placed diagonally and 9 in. above the charging floor. The gases pass off through a down-corner into a main flue ending in a chimney 130 ft. high. The tuyeres are of the Davis pattern.†

The limestone-flux forming 7·28% of the charge contained, SiO_2, 0·5 to 1%; CaO, 54 to 55%. The coke used came from Pocahontas and Loup Creek, W. Va., the cost being $12·64 per net ton delivered. It contained:

	Water	Volatile Material.	Fixed Carbon.	Sulphur.	Phosphorus.	Ash.
	%	%	%	%	%	%
Pocahontas	1·092	2·150	89·078	0·656	0·006	7·024
Loup Creek		2·5	91·9			5·6

The ore-charges treated in 1896 consisted of 33% siliceous and sulphide ore,

* See THE MINERAL INDUSTRY, VII., 460. † See Hofman, *Metallurgy of Lead*, 5th Ed., p. 255.

30% lead ore, 32% argentiferous iron ore and 5% matte. The subjoined analyses give examples of the composition of some of the ore-beds:

ANALYSES OF ORE-BEDS.

Constituents.	SiO_2.	Fe.	CaO.	Zn.	Al_2O_3.	S.	As.	Pb.	Ag.	H_2O.
	%	%	%	%	%	%	%	%	Oz.	%
Lead ores	13·6	21·6	3·3	2·3		1·5		27·0	15·4	12
	19·2	19·3	4·2	3·0		3·0		21·1	26·9	12
	6·5	28·5	2·0	1·2		1·0		18·7	7·8	12
Iron ore	5·5	40·5	2·8	2·6		1·2		8·1	2·5	8
	6·6	35·5	3·0	1·5		1·2		9·0	2·3	8
Silver ores	35·5	7·0	17·8	1·0		4·8	1·0		53·6	8
	44·2	4·6	14·7	2·0		2·4			263·3	8
	73·4	3·5	6·8	1·5		2·3			30·0	
Special ores	15·6	35·9	1·0	6·8	1·7	8·2			32·1	5
	14·3	37·9	0·9	5·6		6·2		1·0	35·9	6

The author considers that with 400-oz. bullion, the charge ought to contain about 12·5% lead. The slags aimed at were:

SiO_2.	FeO.	CaO.	RO.
%	%	%	%
34	34	17	15
32	48	12	8

In the slag-calculation, barium of the barite was not figured in under the head of lime, but was relegated to RO, and an average of the analyses of acid slags made in six months gave: SiO_2, 34·04%; FeO, 34·30%; CaO, 17·35%; Zn, 3%; Pb, 1·1%; Ag, 1·2 oz. per ton with 218-oz. base bullion.

As regards the management of the furnace, the author states that ores saturated with moisture gave better results both as to quality and quantity of work than when dry. He also lays stress on correct feeding. In order to find out whether the coke fully covers the area of the furnace, he advises the use of a wooden frame on the floor. If the coke, when leveled off, does not cover the floor the ore-charge should be made heavier. A lack or an excess of fuel makes itself quickly felt in a correctly-composed slag by the silver and lead it retains. Thus, a slag-assay of 1% Pb and 3 oz. silver per ton indicates an excessive reduction of iron calling for a cutting-down of the fuel, while with 3% Pb and 1 oz. silver per ton the temperature of the furnace is insufficient to reduce or precipitate the lead, and more coke will be required. The richness in silver of a slag is, however, due also to light zinky matte becoming entangled with the slag. As cupreous sulphide has the property of fusing together with zinc sulphide, it is used to keep the slags clean. Thus, the first matte is often made to carry 8 to 12% Cu, but not above 12%, as then the channel of the siphon begins to become clogged. An excess of fuel is also recognized by the production of speise. By cutting down the fuel, the quantity of speise will be diminished, but at the same time the lead-content of the matte increased, and the grade of the bullion lowered by its taking up arsenic; some copper-speise may also form, and the slag may become rich in lead. The author believes it not advisable to run up the lead in the matte higher than 18%. If the fuel is cut down, the blast must be raised, the limit being set by the top of the furnace becoming hot and the crucible cold. In

concentrating matte, some copper-speise hard to crush is liable to form if arsenic be present to any considerable amount. If this speise is resmelted with sulphides foliated iron-speise will be found which readily passes through the rolls.

The base bullion produced is melted down in two cast-iron kettles, 6 ft. 4 in. in diameter and 3 ft. deep, holding 425 bars of lead, each weighing 96 lb. When drossed, the lead is siphoned off into moulds placed in a semi-circle.* The dross, the author advises, should not be returned to the ore-blast furnace, but be put through a separate furnace. An analysis of dross showed: Pb, 91·9181%; Ag, 0·8122%; Au, 0·0038%; Cu, 2·8500%; S, 0·7598%; As, 2·2340%; Sb, 1·3400%; Fe, 0·0521%; Ni, trace; Co, trace; Bi, not determined. An analysis of 1,482 tons of speise gave: Fe, 71·6%; As, 15·6%; S, 5·5%; Cu, 1·2%; Pb, 3·5%; not determined, 2·6%; Ag, 14·3 oz., Au, 0·08 oz. per ton. Analyses of roasted matte to be used as iron flux in the ore-blast furnace showed: SiO_2, 0·8%; Fe, 42 to 45%; S, 2·8 to 4·2%; Cu, 3·1 to 9·2%; Pb, 13%; Ag, 67 to 100 oz. When the copper exceeded 9%, the matte, after having been roasted, was smelted in a separate blast furnace with siliceous ores, metallic iron, limestone and lead dross and scrap for concentrated shipping matte: Cu, 37·5%; Pb, 12·0%; Ag, 157·3 oz. An average of 100 slag analyses made in concentrating matte showed SiO_2, 41·0%; FeO, 32·8% (=Fe, 25·5%); CaO, 16·0%; RO, 10·2%; Pb, 0·8%. The flue-dust saved in ore-smelting amounted to 1·2% on the dry weight of the ore. It was wetted down, mixed with loam, moulded by hand into bricks (8·5×4·5×2·5 in.), air-dried and kiln-burnt. A baked brick weighed 3·5 lb. and had the following composition: SiO_2, 19·0%; Fe, 22·0%; CaO, 6·0%; Zn, 2·0%; S, 2·4%; Pb, 16·2%; Ag, 28·2 oz., Au, 0·105 oz. per ton.

The cost of smelting, excluding roasting, was $6·86 (Mexican) per ton of ore.

Lead Slags.—Cáp† publishes the following four average analyses of lead-blast furnace slags made at Przibram, Bohemia, between 1890 and 1898.

AVERAGE YEARLY ANALYSES OF PRZIBRAM LEAD SLAGS.

Constituents.	1890.		1891.		1893.		1898.	
	%	Corresponding % O.	%	Corresponding % O.	%	Corresponding % O.	%	Corresponding % O.
SiO_2	28·00	14·93	27·80	14·82	33·35	17·77	35·79	19·04
P_2O_5	1·10	0·61	1·60	0·90	1·10	0·61	1·90	0·67
Al_2O_3	5·54	2·59	4·70	2·19	6·10	2·85	4·81	2·24
CaO	10·86	3·16	16·95	4·84	16·80	4·80	16·50	4·71
MgO	0·68	0·27	1·05	0·42	1·47	0·59	1·58	0·63
FeO	35·83	7·95	33·00	7·32	27·10	6·02	29·50	6·55
MnO	3·00	0·68	3·40	0·76	3·40	0·76	2·10	0·47
ZnO	9·43	1·86	7·09	1·39	6·90	1·36	6·00	1·18
PbO	1·67	0·12	0·70	0·05	1·70	0·12	1·50	0·11
Ag	0·002		0·0017		0·0025		0·0025	
S	2·52		1·60		1·50		1·50	
Sb, As	Trace.		Trace.		Trace.		Trace.	
CoNi	Trace.		Trace.		Trace.		Trace.	
CuO	Trace.		Trace.		Trace.		Trace.	
Total	98·642		97·8917		99·4225		100·3825	
O for S	1·260						0·75	
Leaves	97·382						99·6325	
O in acid: O in base	15·54	16·63	15·72	16·97	18·38	16·50	19·71	15·89

The slag made in 1890 is a singulo-silicate, running low in lime. When running from the furnace it is below a clear cherry to orange red, solidifies quickly, does not allow the matte to settle out completely and causes short campaigns of

*See Hofman, *op. cit.* †*O. Z.*, 1900, 231.

the furnace, on the average of not more than three months' duration. The slag of 1891 is also a singulo-silicate, but it runs higher in lime (magnesia) and lower in ferrous oxide (manganous oxide) than the slag of 1890, the proportion of the two being 1 to 2. It was found that the slag became less readily fusible if in a singulo-silicate the lime was increased above this proportion. Retaining this ratio of lime and ferrous oxide, experiments were made to raise the silicate degree, as shown by the analyses of 1893 and 1898. The slags are a clear cherry to orange red when running from the furnace and are fluid; they have a low specific gravity and permit the furnace to make campaigns of from 9 to 15 months' duration. It was found that with the lime ferrous-oxide ratio of 1 to 2, slags of a silicate degree 1·1 to 1·3 always gave most satisfactory results.

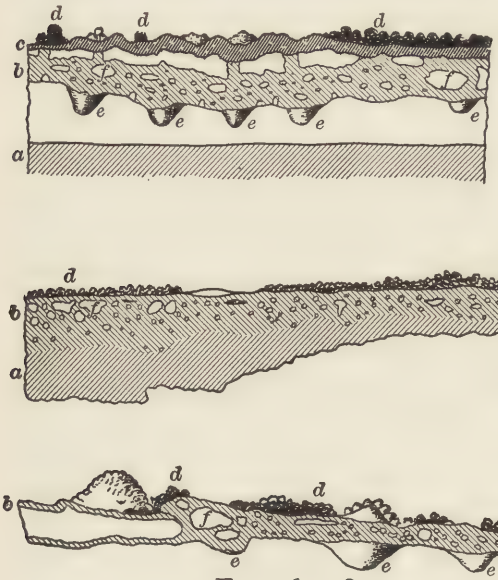
The Blast.—Klink* and Willis-Boyd-Hill† patented new forms of tuyeres; Wells,‡ a device for utilizing the heat of molten slag for superheating the blast. The discussion between Lang§ and Bretherton‖ over the Bretherton's apparatus¶ for superheating the blast by means of the heat of the waste slag, has probably now come to a close.

Matte.—Vambere** discusses the settling-out of matte from slag, basing his views on a detailed investigation of the products of the silver-lead works of Przibram, Bohemia. The ores, galena concentrates, treated in 1896 contained: Pb, 26·13% and Ag, 58·8 oz. per ton. The analysis of an average sample gave: Pb, 26·250%; Ag, 0·209 oz.; Cu, 0·124%; As, 0·404%; Sb, 0·897%; Sn, 0·065%; Fe=2·590% (as FeS_2) Fe=7·720% (soluble in HCl); Zn, 6·520%; Mn, 1·152%; CaO, 1·344%; MgO, 0·514%; Al_2O_3, 1·690%; SiO_2, 28·620%; CO_2, 8·611%; S, 10·830%; Ni, Bi, Cd and BaO, traces.

The ores are roasted in hand reverberatory furnaces with fusing hearths where the roasted ore is slagged. They retain S 1·2 to 1·4%, and are then smelted with 12·5% coke and a small addition of charcoal in blast furnaces having internal crucibles and Arent's siphon-taps. With 100 parts slag and roasted galena ore, are charged 1·35 parts flue-dust, the whole assaying Pb, 26·3% and Ag, 58·04 oz. per ton. To this are added 139·34 parts rich slags, furnace refuse and matte, 37·163 parts intermediary lead products from the Pattinson desilverizing plant and the cupelling furnaces, and 47·56 parts iron ore and limestone, making a total of 325·413 parts with Pb 17·6% and Ag 22·75 oz. per ton. For every 100 parts ore charge there are produced 17 parts base bullion (Pb, 98%; Ag, 117·54 oz.), 1·9 parts matte (Pb, 18%; Ag, 18·37 oz.), 0·11 parts flue-dust (Pb, 37%; Ag, 6·42 oz.) and 98 parts slag, some of which is resmelted, *i.e.*, when it contains over 2% Pb and 0·87 oz. Ag per ton. Occasionally, when the percentage of iron is high or that of sulphur low, some (so-called) speise is produced: Fe, 40%; Pb, 2%; As, 6 to 7% (?); Ni, 1%; (Rest?). Slag and matte are tapped into conical slag-pots and allowed to cool. Figs. 6, 7 and 8 represent sections of the upper part of a slag-cone: *a*=body of slag, crystalline, with smooth horizontal surface; *b*=intermediary slag, glassy, bluish-black, with bubbles; *c*=top slag,

* United States Patent No. 663,177, Dec. 24, 1900.
† United States Patent No. 663,205, Dec. 4, 1900.
‡ United States Patent No. 657,843, Sept. 11, 1900.
§ *E. & M. J.*, April 28, Sept. 22, 1900.
‖ *Ibid.*, May 26, Oct. 20, 1900.
¶ *Ibid.*, Nov. 18, Dec. 9, 1899.
** *O. J.*, 1900, 1–64.

uneven surface, partly smooth and dense, partly spongy; *d*=nodular excrescences; *e*=droplets, glassy, smooth surface. An analysis of the crust gave Ag, 0·055 oz.; Pb, 8·70%; CuO, 0·07%; Bi, trace; As, 0·10%; Sb, 0·28%; Sn, 0·29%; Fe, 20·65%; Zn, 5·86%; Mn, 1·80%; NiCo, 0·09%; SiO_2, 28·36%; Al_2O_3, 4·55%; CaO, 13·66%; MgO, 0·79%; S, 5·49%. The powdered



FIGS. 6, 7, 8.
UPPER CRUSTS OF SLAG.

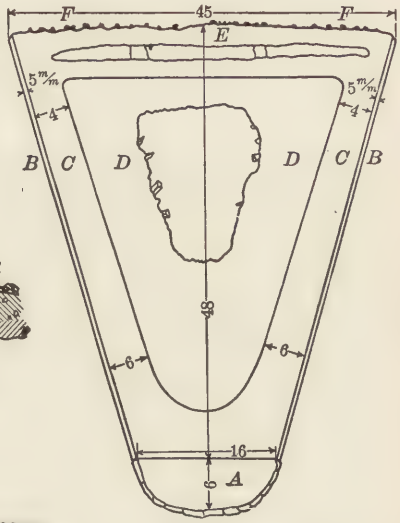


FIG. 9
VERTICAL SECTION THROUGH SLAG-POT SHOWING METHOD OF SAMPLING.

sample was black and had a sp. gr. of 3·79. The high percentage of sulphur shows that the richness of the slag is due to an imperfect separation of sulphides. In order to examine the distribution of compounds in a slag-cone, the author took four samples as shown in Fig. 9. *A*=matte; *C* and *D*, dense crystalline slag containing sometimes pellets of matte and even globules of lead;

ANALYSIS, HARDNESS AND SPECIFIC GRAVITY OF PRZIBRAM SLAG COOLED IN POT.

	Part B.	Part C.	Part D.
	%	%	%
Ag	0·005	0·0035	0·0035
Pb	3·09	2·89	2·40
Cu	0·11	6·02	0·04
Fe	22·27	21·50	21·27
S	0·35	0·75	1·17
SiO_2	33·29	33·98	34·51
Hardness	7	6	5·5
Sp. Gr. at 4° C.	3·727	3·758	3·725

E=upper slag (section, see Fig. 8); *F*=nodular excrescences (in order to obtain sufficient material for examination, samples had to be collected from a number of slag-cones); *B*=shell of chilled slag, frequently contains pellets of matte 1 to 3 mm. in diameter. The center of the cone *D* is crystalline and does not show any suspended particles of matte or lead.

ANALYSES OF PRZIBRAM MATTE AND SLAGS.

	Matte.					Crystalline Slag.				
	%	Corresponding O %	S %	Corresponding SO_3 %	Total %	%	Corresponding O %	S %	Corresponding SO_3 %	Total %
Ag	0·142		0·02		0·162 Ag_2S	*b*0·003		Trace	0·11	*b*0·003 Ag_2S
Pb	3·69	0·14			1·95 PbO	0·28	0·02			0·41 $PbSO_4$
Pb	1·81	0·29		1·43	5·41 $PbSO_4$	0·13	0·01			0·14 PbO
Pb	26·56		4·11		30·67 PbS	*b*2·75		0·43		*b*3·18 PbS
Cu	1·79		0·45		2·24 Cu_2S	0·04		0·01		0·05 Cu_2S
Bi	0·15		0·06		0·21 Bi_2S_3	*b* Trace.				*b* Trace. Bi_2S_3
As	0·15		0·09		0·24 As_2S_3	*b*0·12		*b*0·07		*b*0·19 As_2S_3
Sb	0·29		0·11		0·40 Sb_2S_3	*b*0·09		*b*0·03		*b*0·12 Sb_2S_3
Sn	0·64		0·17		0·81 SnS	*b*0·21		*b*0·06		*b*0·27 SnS
Fe	*a*0·34	0·09			*a*0·43 FeO	21·65	6·19			27·84 FeO
Fe	7·56	2·16			9·72 FeO					
Fe	19·58		11·19		30·77 FeS	1·03		0·59		*b*1·62 FeS
Fe	4·70				4·70 Fe	*b*0·30				*b*0·30 Fe
Zn	*a*0·06	0·01			0·07 ZnO	4·23	1·04			5·27 ZnO
Zn	1·02	0·25			1·27 ZnO					
Zn	4·90		2·41		7·31 ZnS	*b*0·51		*b*0·25		*b*0·76 ZnS
Mn	*a*0·04	0·01			0·05 MnO	3·78	1·10			4·88 MnO
Mn	0·06		0·013		0·09 MnS	*b* Trace.		Trace		Trace. MnS
Ni	0·08		0·43		1·23 NiS	*b*0·08		0·04		*b*0·12 NiCoS
Co					CoS	0·03	0·01			0·04 NiCoO
SiO_2	*a*0·49				*a*0·49 SiO_2	31·56				31·56 SiO_2
Al_2O_3	0·21				*a*0·21 Al_2O_3	3·88				3·88 Al_2O_3
BaO					 BaO	Trace.				Trace. BaO
CaO	*a*0·51				*a*0·51 CaO	16·47				16·47 CaO
MgO	*a*0·04				*a*0·04 MgO	0·36				0·36 MgO
K	0·12		0·04		0·16 K_2S	0·22 K_2O				0·22 K_2O
Na	0·20		0·13		0·33 Na_2S	0·17 Na_2O				0·17 Na_2O
P_2O_5	Trace.				Trace. P_2O_5	1·04				1·04 P_2O_5
	78·852	2·95	19·24	1·43	99·472	88·033	8·37	1·48	0·11	98·893

(*a*) Calculated as slag-constituent. (*b*) Calculated as matte-constituent.

ANALYSES OF PRZIBRAM MATTE AND SLAGS.—*Concluded.*

	Upper Slag.					Slag Excrescences.				
	%	Corresponding O %	S %	Corresponding SO_3 %	Total %	%	Corresponding O %	S %	Corresponding SO_3 %	Total %
Ag	0·058		0·008		0·066 Ag_2S	0·208		0·03		0·238 Ag_2S
Pb	3·68	0·29		5·41	5·41 $PbSO_4$	20·34	1·57		7·87	29·78 $PbSO_4$
Pb	10·73	0·83			11·56 PbO	9·99	0·77			10·76 PbO
Pb	1·49		0·23		1·72 PbS	11·99		1·86		13·85 PbS
Cu	0·78		0·19		0·97 Cu_2S	2·64		0·66		3·30 Cu_2S
Bi	0·08		0·02		0·10 Bi_2S_3	0·16		0·04		0·20 Bi_2S_3
As	0·09		0·05		0·14 As_2S_3	0·27		0·17		0·44 As_2S_3
Sb	0·16		0·06		0·22 Sb_2S_3	0·19		0·07		0·26 Sb_2S_3
Sn	0·05		0·04		0·09 SnS	0·05		0·01		0·06 SnS
Fe	*c*13·19	3·77			*c*16·96 FeO	*d*0·94	*d*0·26			*d*1·20 FeO
Fe	5·55	1·58			7·13 FeO	18·39	5·25			23·64 FeO
Fe	6·32		3·61		9·93 FeS	3·53		2·02		5·55 FeS
Fe						0·56		0·27		0·83 ZnS
Zn	*c*2·56	0·63			*c*3·19 ZnO	*d*0·17	0·04			*d*0·21 ZnO
Zn	0·62	0·16		0·77	1·55 $ZnSO_4$	1·64	0·41		2·03	4·08 $ZnSO_4$
Zn	2·07	0·51			2·58 ZnO	0·19	0·04			0·23 ZnO
Mn	*c*2·02	0·59			*c*2·61 MnO	*d*0·16	0·04			*d*0·20 MnO
Mn						0·16		0·09		0·25 MnS
Ni	0·15		0·08		0·23 NiCoS	0·16		0·08		0·24 NiCoS
Co										
SiO_2	*c*19·11				*c*19·11 SiO_2	*d*1·35				*d*1·35 SiO_2
Al_2O_3	*c*3·02				*c*3·02 Al_2O_3	*d*1·11				*d*1·11 Al_2O_3
BaO					 BaO					 BaO
CaO	*c*10·35				*c*10·35 CaO	*d*1·46				*d*1·46 CaO
MgO	*c*0·32				*c*0·32 MgO	*d*0·24				*d*0·24 MgO
K	0·35 K_2O				0·35 K_2O	0·15K_2O				0·15 K_2O
Na	0·30 Na_2O				0·30 Na_2O	0·10Na_2O				0·10 Na_2O
P_2O_5	*c*0·78				*c*0·78 P_2O_5					 P_2O_5
	83·828	8·36	4·288	2·21	98·686	76·148	8·38	5·30	9·90	99·728

(*c*) Calculated as slag-constitueut. (*d*) Calculated as slag-constituent.

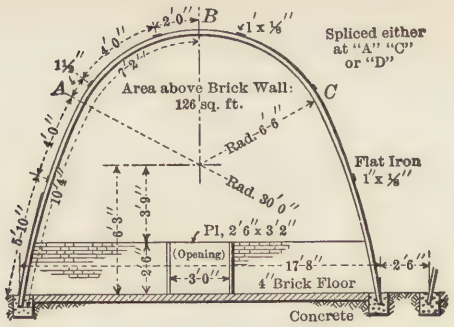


FIG. 10.—Transverse Section.

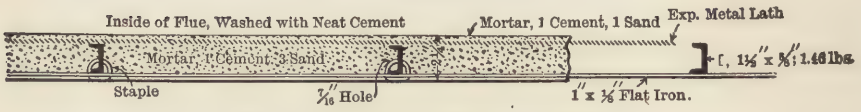


FIG. 11.—Longitudinal Section of Side Wall.

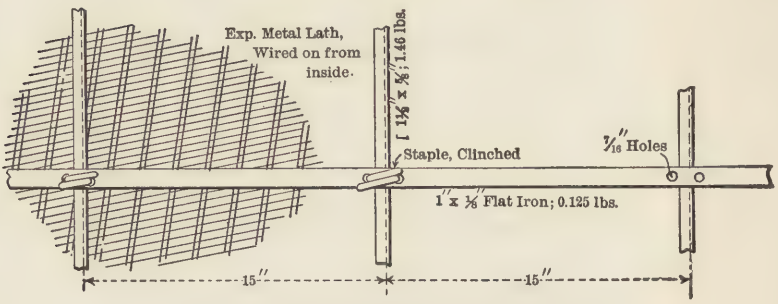


FIG. 12.—Part Side Elevation, showing construction.

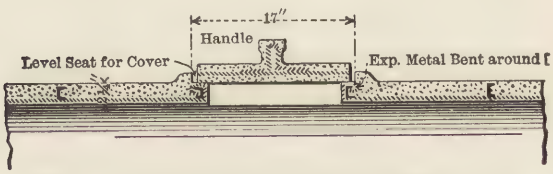


FIG. 13.—Longitudinal Section, showing opening in crown.

DUST FLUE OF CONCRETE AND STEEL.

In the course of his tests the author determined the melting point of the matte to be 880°C. and that of the slag 1,070°C. Experiments to separate particles of iron and lead from the slag by washing proved unsuccessful, *viz.:*

	Heads.	Tailings.
Sp. Gr.	3·693	3·661
Per cent. of total	41	59
Ag %	0·0045	0·0035
Pb %	3·03	2·97
Cu %	0·08	0·03
S %	1·08	0·97
SiO_2 %	34·15	34·04

Flue-Dust.—At the works of the Arkansas Valley Smelting Co., Leadville, Colo.,* a new dust flue of concrete and steel has been constructed by E. H. Messiter to convey the gases from the roasting furnaces to the stack. Details are given in Figs. 10 to 13. The transverse section (Fig. 10) represents channel-iron hoops, 15 in. apart, bent to an arch with the ends set in concrete base-walls. Longitudinally the arches are connected by bars of flat iron which are fastened to the channels by clinched staples (Fig. 11). The floor of the flue is of brick and carries at intervals low partition walls (Fig. 10), which prevent the dust, once settled out, from being carried off by the gas-current. To the inside of the channels and flat-iron bars is wired a lathing of expanded metal (Fig. 12); the whole is embedded in cement concrete (1 part German cement to 3 parts sand) making a wall 2·25 in. thick; at the crown slag-concrete is used. The inside is coated with a mortar, consisting of equal parts of cement and sand, and this given a wash of neat cement. Fig. 13 represents one of the openings in the crown; in the sides doors, closed by iron plates, are left for removing the flue-dust. The construction is rigid and is considered to be an improvement on the original Monier flue.† N. P. Wood‡ describes a circular hood placed by J. B. Seger over the stack of a copper blast furnace at Helvetia, Ariz., which reversing the gas-current before it passes into the open air, causes it to drop a large part of the flue-dust it carried out of the furnace. The hood is shown in Fig. 14. The flue-dust saved amounted to 4·26% of the weight of the ore charged. With charges containing 5, 6, 7, 8, 9 and 10% copper the flue-dust assayed 3·1, 3·7, 4·3, 5·0, 5·8 and 6·5% Cu. Chemical analyses of the products obtained by screening the dust through graded sieves gave the following:

Size of Screen.	Per cent. caught.	Cu.	SiO_2.	Fe.	CaO.
		%	%	%	%
On 20-mesh.....	0·5	None.			
" 40 "	16·3	3·8	37·0	11·4	21·5
" 60 "	31·8	3·9	35·2	13·2	22·7
" 80 "	13·1	4·2	38·2	15·0	20·7
" 100 "	5·7	4·5	40·7	14·4	19·0
Through 100-mesh.....	32·3	4·7	44·0	15·0	14·5

At one of the leading smelting plants of the country the Freudenberg§ principle of divided flues has been applied in a modified form. Near the stack the dust flue is divided into three branches, two of which are usually cut out together. The dust, which consists mainly of finely-divided coke, is fired and the products of combustion are conducted in to the third flue, which carries them off to the stack. In this way the amount of dust that has to be bricked and charged back into the blast furnace is greatly diminished.

Iles‖ describes his experimental apparatus for collecting solids from smoke. The dust-laden gases are passed by the aid of a Sturtevant blower into a sheet-iron box surmounted by a muslin or flannel bag 30 in. diameter and 60 ft. high, which serves as a filter; the removed dust falls to the bottom and is collected in

* *Eng. News*, 1899, XLII., 356.

† THE MINERAL INDUSTRY, IV., 479, and Hofman, *Metallurgy of Lead*, 5th Ed., page 383.

‡ *M. & S. P.*, June 30, 1900. § *B. & H. Ztg.*, 1883, 535. ‖ *E. & M. J.*, June 2, 1900.

the box. The pressure gauge used by Iles in his tests* is the Fallis manometer. This apparatus, according to Brown,† is a modification of an instrument invented by Wollaston many years ago and described by Atkinson.‡ Another similar instrument is the Koenig water-gauge.§

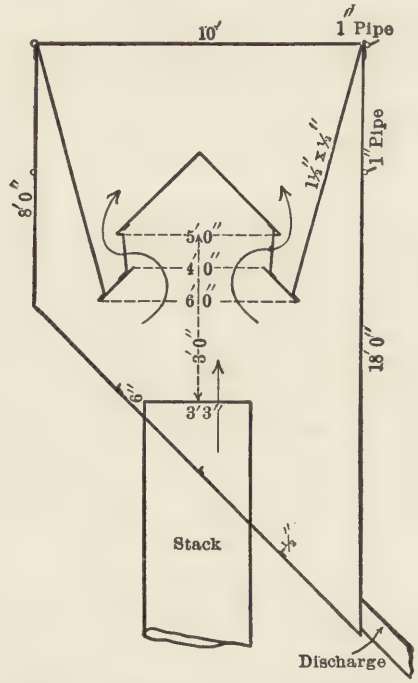


FIG. 14.—DUST COLLECTOR PLACED ABOVE THE STACK OF A COPPER BLAST FURNACE.

Ruetschi patented‖ a device for condensing flue-dust which aims (1) to cool the gases that part of the dust may settle out; (2) to force them onward and at the same time to dilute them with air; (3) to split up the diluted gases into a number of branches, and (4) to give each a whirling motion, when with the assistance of cooling devices the remaining solid matter will be precipitated.

Cost of Smelting.—Iles¶ gives some data on the cost of smelting at the works of the Globe Smelting and Refining Co., Denver, Colo., for the years 1887-1898. They are summarized in the subjoined table:

Year.	Cost of Smelting 1 ton of Ore.	Area of Furnace at Tuyeres.	Working Height of Furnace.	Blast Pressure.	Fore-Hearth Capacity.	Slag Settled.	Fuel.	Slag Removed.	Matte Removed
	$	In.	Ft.	Lbs. per sq. in.	Cu. ft.			Lbs. per trip.	Lbs. per trip.
1887.....	4·644	30×100	11	1	6	In pots.	Charcoal.	By hand, 200	By hand, 200
1898.....	2·260	42×140	16	3-4	(a)128	Furnaces. (a)	Coke.	By locomotive, 3,000-6,000	By horse, 2,000-3,000

(a) Refers to the Iles reverberatory settling furnace.

* *E. & M. J.*, June 30, 1900.
† *Ibid.*, July 28, 1900.
‡ *Trans. North England Inst. Min. & Mech. Eng.*, III., 168.
§ *Trans. Inst. Min. Eng.*, III., 452.
‖ United States Patent No. 652,045, June 19, 1900.
¶ *E. & M. J.*, March 3, Aug. 18, 1900.

The author believes that a further reduction of cost can be had by substituting more mechanical work for hand work, and by the use of a better coke, the coke used at present containing 16 to 22% ash.

DESILVERIZATION OF BASE BULLION.

Pattinson Process.—Tredinnick patented* a hydraulic device for raising and lowering with their fire-places kettles in which argentiferous lead is to be desilverized by the Pattinson or the Luce-Rozan process.

Parkes Process.—The Preble Machine Works of South Chicago† published an illustration of an oval cast-iron desilverizing kettle made for the South Chicago desilverizing works of the American Smelting and Refining Co. Its inside dimensions are: Width, 9 ft.; length, 15 ft. 14 in.; depth, 4 ft. 5 in.; it has a 9-in. flange, the radii of the circles are 4 ft. 8 in., the thickness is 2 in.

Rodda‡ proposes to treat zinc crusts in a baby-cupola supported by trunnions, the fumes to be collected in a condenser and the lead to be tapped into moulds.

Iles§ gives the cost of refining base bullion at the works of the Globe Smelting and Refining Co., as varying between $3 and $5 per ton. If interest, expressage, brokerage, treatment of by-product, are added, the total cost rises to about $10 per ton. The following gives the details of total cost, including the parting of doré silver: Labor, $1·968; spelter, $0·861; coal, $0·496; coke, $0·521; supplies, repairs and general expense, $0·289; interest, $1·317; expressage, $1·085; parting and brokerage, $2·121; re-working by-products, $1·492; total, $10·151; tons bullion refined, 8,287·99. In 1898 the average cost of refining alone was $3·45 per ton, the reduction being due to the greater purity of the bullion and to the introduction of the Howard press and stirrer.‖

Electro-Deposition of Lead.—Glaser¶ discusses the electro-deposition of lead from solutions and the formation of spongy lead.

*Electrolytic Lead Reduction.***—The Electrical Lead Reduction Co. at Niagara Falls, N. Y., has equipped its new plant with two Westinghouse 300-H.P. motors, direct-connected to a Westinghouse direct-current 250-H.P. generator. Theoretically the process consists of the electrolytic reduction from galena of spongy lead which may be compressed into the form of storage battery plates or converted into litharge, red lead, lead peroxide or white lead, 100 lb. of spongy lead yielding respectively 108 lb. litharge, 110 lb. red lead, 116 lb. lead peroxide or 125 lb. white lead. Sulphuric acid is a by-product, 800 lb. being produced per ton of lead. High-grade galena concentrates from Joplin, Mo., are treated, requiring five days for reduction to spongy lead, which is washed and oxidized to litharge in a furnace yielding a product of 99·36% purity. At the beginning of 1901 the work of the company was confined to the production of litharge, although machinery was being installed to roll and stamp the sponge into plates for storage batteries.

* United States Patent No. 662,836, Nov. 27, 1900.
† *I. T. R.*, Nov. 1, 1900.
‡ *E. & M. J.*, Oct. 27, 1900.
§ *E. & M. J.*, Aug. 18, 1900.
‖ Hofman, *op. cit.*, pp. 460, 455.
¶ *Z. E. Ch.*, VII., 365.
** *Electrical World and Engineer*, Jan. 19, 1901.

MAGNESIUM AND MAGNESITE.

THE production of magnesite in 1900 was confined, as heretofore, to the State of California, and amounted to 2,708 short tons, against 2,000 tons in 1899. No statistics are available as to the imports of magnesite bricks, which are of considerable importance, but the importation of crude magnesite in 1900 was 28,821 short tons, an increase of 8,014 tons over the figures for the preceding year. Greece and Styria are the chief sources of supply for magnesite.

PRODUCTION OF MAGNESITE IN CALIFORNIA.

Year.	Crude.			Calcined.		Crude Equivalent of Calcined. Short Tons.	Total Crude.	
	Short Tons.	Value at Mine.	Per Ton.	Short Tons.	Value at Works.		Short Tons.	Value.
1896.....	489	$2,300	$4·70	789	$11,135	1,578	2,067	$9,715
1897.....	379	1,516	4·00	764	10,700	1,528	1,907	7,628
1898.....	200	800	4·00	1,013	14,200	2,155	2,355	9,420
1899.....	400	1,200	3·00	800	12,200	1,600	2,000	7,600
1900.....	469	1,876	4·00	1,013	15,900	2,239	2,708	11,832

The consumption of magnesite in the United States is increasing rapidly owing to its extensive application as a refractory lining for basic open-hearth furnaces and converters in the steel industry and for rotary kilns in the manufacture of Portland cement. There is also a growing demand for it among the makers of carbon dioxide. Magnesite bricks for refractory linings are made in this country by the Fayette Manufacturing Co. at Layton, Pa., and by the Harbison & Walker Co., at Pittsburg, Pa. The latter company manufactures two grades of bricks. For the most refractory grade, No. 1, which contains 96 to 98% MgO, Grecian magnesite is used, while No. 2 grade is made of a mixture of Grecian material with Austrian. The Austrian magnesite when "dead" burned analyzes about as follows: MgO, 89%; Fe_2O_3, 7%; SiO_2, 2%; Al_2O_3, 1%; CaO, trace. Before shaping into brick the magnesite is burned absolutely "dead" at a temperature of 3,000 to 3,500°F. The company manufactures about 8,000 bricks per day, which are sold to steel and cement manufacturers and to the smelters of lead, copper and other metals. The bricks made by the Fayette Co. are manufactured from Carl Spaeter, Austrian magnesite.

The superiority of magnesite over dolomite as a refractory material is due to its non-hygroscopic character after burning and to the fact that it can be used for repeated operations. Owing to its lime content, dolomite shows a tendency to air-slake and disintegrate after a heat. It is stated that in European open-hearth steel practice from 33 to 44 lb. magnesite are consumed for each ton of steel produced, including that used for the building of the furnace. In ordinary working the amount required for repairs ranges from 110 to 220 lb. per furnace, while with a similar furnace lined with dolomite the requirement is from 550 to 1,100 lb.

Austria.—There are important magnesite mines at Mittendorf, Styria and at Minsan, Hungary. The following analyses show the character of the crude and calcined materials:

	MgO.	CO_2.	Fe_2O_3.	Al_2O_3.	SiO_2.	CaO.	FeO.	Loss.
Crude magnesite, Hungary	45·28	49·56		1·10	0·80	0·06	3·20	
Crude magnesite, Styria	43·22	47·25			0·92	2·64		
Calcined magnesite, Hungary	90·42	0·46	5·02	2·38	0·17	1·50		0·05
Magnesite bricks, Hungary	91·52		6·05		0·35	2·10		
Magnesite bricks, Styria	83·00		7·60	1·30	3·45	3·90		0·20

As to the magnitude of the operations at Mittendorf, Carl Spaeter states that the sales of magnesia and magnesite in 1899 amounted to 47,000 tons.

Greece.—The production of magnesite in 1900 was 17,277 metric tons crude, 807 tons calcined magnesite and 534 tons bricks. The deposits at Mantoudi and Limni on the island of Euboea are worked by the Société des Travaux Publiques et Communaux of Athens and by the Petrifite, Ltd., the latter being an English company. Other occurrences at Pyli near Megara, in Locris and Phthivdis are owned by La Société d'Enterprise Generale, Ziller & Christomanos, M. B. Boudouri and others. An analysis of magnesite from Mantoudi, Euboea, shows 95·12% $MgCO_3$, 4·02% $CaCO_3$, 0·52% SiO_2, 0·34% H_2O and trace FeO. The price of magnesite f. o. b. nearest shipping port is about 23 fr. ($4·44) per metric ton. The greater part of the exports is shipped to the United States.

Russia.—Rich deposits of magnesite have been reported from the Ufa district. The ore analyzed MgO, 46%; CaO, 0·85%; Fe_2O_3, Al_2O_3, 1·62%; SiO_2, 0·3%, and CO_2, 51·23%. A company with a capital of 200,000 rubles has been formed to exploit this deposit and to manufacture magnesite bricks.

MANGANESE.

THE production of manganese ores of all grades in the United States during 1900 is given in the subjoined table. This does not include the manganiferous iron ores of Colorado and other Western States consumed as a flux in silver-lead smelting, although account is taken of that portion sold to steel makers for the manufacture of ferromanganese and spiegeleisen. The average manganese content of the ores from the different States is shown in the table on the next page. For details as to the American consumption and supply reference may be made to the article by Alfred A. Wheeler in THE MINERAL INDUSTRY, Vol. VIII., while the composition and occurrence of the ores of manganese have been fully set forth in the preceding volumes.

The subjoined table shows the relative production during 1899 and 1900 of the high-grade ore from Arkansas, California, Georgia, Tennessee and Virginia; of Colorado ores used for steel making purposes; of the low-grade ores from Michigan and Wisconsin, and of the manganiferous residuum from the zinc oxide works of New Jersey and Pennsylvania.

STATISTICS OF MANGANESE ORE IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Year.	Production.											Imports.		Consumption.	
	Arkansas.	California.	Colorado	Georgia.	Michigan and Wisconsin.	New Jersey.	Tennessee.	Virginia.	Elsewh're	Totals. Tons.	Totals. Value.	Tons.	Value.	Tons.	Value.
					a	*b*									
1896	3,038	318	9,072	2,538	110,317	35,655		1,588		162,526	$339,083	31,489	$250,468	194,015	$589,551
1897	4,430	450	18,600	962	80,261	50,000	190	2,408	c1,300	158,600	328,176	39,574	340,945	198,174	669,121
1898	2,775	393	17,792	2,477	112,318	47,470	1,250	3,307		187,782	416,627	114,885	831,967	302,667	1,248,594
1899	855	263	29,161	1,623	53,702	53,921	30	3,626	75	143,256	306,476	188,349	1,584,528	331,605	1,891,004
1900	51	231	45,791	1,053	75,360	91,748	*Nil.*	3,988		218,222	461,994	256,252	2,042,361	474,474	2,504,355

(*a*) Manganiferous iron ore. (*b*) Franklinite residuum. (*c*) Vermont manganiferous iron ore.

MANGANESE PRODUCTION AND CONSUMPTION OF THE UNITED STATES ON A BASIS OF 50%MN CONTENT (IN TONS OF 2,240 LB.)

Year.	50% Ores from Ark., Ga., Va., Cal. & Tenn.	30% Ore from Colorado.	12% Ore from New Jersey	7% Ore from Mich. and Wisconsin.	Equivalent Total Tonnage of 50% Ore.	Imported Ores of 50% Grade.	Total Consumpt'n of 50% Grade & Equivalent.	Per Cent. of Imp'd Ore.
1896.....	7,482	9,072	35,655	110,317	36,925	31,489	68,414	46·0
1897	8,440	18,600	50,000	80,261	42,836	39,574	82,310	48·1
1898.....	9,902	17,792	47,470	142,318	51,295	114,885	166,180	69·1
1899.....	6,397	29,161	53,921	53,702	44,353	188,349	232,702	80·1
1900	5,323	45,791	91,748	75,360	65,368	256,252	321,620	79·7

The price of manganese ore is determined by the Illinois Steel Co., according to the following schedule which is based on ores containing not more than 8% SiO_2 and 0·1% P. Deductions are made of 15c. per ton for each 1% of SiO_2 in excess of 8%, and of 1c. per unit of manganese for each 0·02% P in excess of 0·1%. Ores delivered at the works of the company, South Chicago, Ill. Settlements are based on analysis of samples dried at 212°F.; the percentage of moisture in the samples as taken being deducted from the weight.

Tenor in Mn.	Price per Unit.		Tenor in Mn.	Price per Unit.	
%	Fe.	Mn.	%	Fe.	Mn.
Over 49.	6c.	29c.	37 to 40	5c.	25c.
46 to 49	6c.	28c.	34 to 37	5c.	24c.
43 to 46	5c.	28c.	31 to 34	4c.	23c.
40 to 43	5c.	26c.	28 to 31	4c.	21c.

Schedules of prices offered by the Carnegie Steel Co. differed but slightly in detail from the above, being about 1c. per unit lower for manganese.

California.—The production of manganese ore in 1900 was limited almost entirely to the region about Livermore, and amounted to only 331 long tons. As most of the gold ores are now smelted instead of being treated by the chlorination process the demand for manganese has fallen off.

Colorado.—The production of manganese ores according to the report of the Hon. Harry A. Lee, amounted to 66,607 long tons, averaging 23% Mn content, and valued at $2·75 per ton at the mines. The consumption of manganese ores is divided between the Colorado Fuel & Iron Co. and the Illinois Steel Co. for the manufacture of spiegeleisen and ferromanganese. The actual shipments during the year amounted to 45,791 long tons as against 29,161 long tons in 1899. The ore consumed in the State averaged 30% Mn content, while that shipped to Chicago ranged between 18 and 32% Mn, presumably the larger part being of the greater richness. An analysis of a shipment from the Modoc mine, one of the largest producers in Colorado, gave Mn, 27·3%; Fe, 23·94%; P, 0·038%; SiO_2, 4·46%; H_2O, 13·32%.

Georgia.—The principal developments in Bartow County during 1900 were the discovery of a large deposit on the property of the Etowah Iron Co. by Knight & Barron, the opening of a new mine by the Brittain & Crea Mining Co., and the resumption of operations in the Chumley Hill mine by Joel Hurt of Atlanta. The Cartersville Manganese & Mining Co. made no production during the year.

Michigan.—The Clark copper mine in Ontonagon County was reopened after several years' idleness for the purpose of exploiting a vein of pyrolusite. New machinery was installed, but the production was limited to a few tons of ore as the vein pinched out in depth.

Pennsylvania.—The Bittenbender mine in Berks County produced about 55,000 tons of manganiferous iron ore in 1900. An average sample of 80 carloads of this ore gave the following results on analysis: Mn, 2·11%; Fe, 32·82%; P, 0·043%; S, 0·117%; Si, 11·07%. While very low grade the ore can be used by local works for introducing a small proportion of manganese into basic pig iron.

Virginia.—The Crimora Manganese Co. was in operation during the first

half of 1900, shipping 874 long tons of ore. Since operations were commenced in 1867, it is estimated that the output has amounted to more than 150,000 tons. The ore is found scattered in irregular masses through a bed of clay which has an area of about 80 acres and a depth of from 1 to 160 ft. Mining was conducted by hydraulicking, the clay being washed through a drainage channel into the Shenandoah River, 4 miles distant, while the ore was collected and hoisted from the pit by means of belt conveyors to a mill where it was submitted to further washing and was then crushed and sized.

WORLD'S PRODUCTION OF MANGANESE ORE. (*a*) (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Bosnia. (*b*)	Brazil. (*e*)	Canada	Chile. (*d*)	Colombia.	France.	Germany	Greece.	India.
1895.....	7,733	22,478	8,145	5,490	113	24,075	6,025	30,871	41,327	7,250	16,070
1896.....	5,941	23,265	6,821	14,120	112	26,152	10,668	31,318	45,062	15,500	57,783
1897.....	10,043	28,372	5,344	16,054	14	23,528	8,382	37,212	46,427	11,868	74,862
1898.....	14,219	16,440	5,320	26,417	45	20,851	11,176	31,935	43,354	14,097	61,469
1899.....	10,484		5,270	65,000	279	40,931	10,160	39,897	61,329	17,600	88,520

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	South Australia (*d*)	Spain.	Sweden.	United Kingdom.	United States.
1895....	1,569	17,141	213	1,240	361	203,081	49	10,162	3,117	1,293	173,237
1896....	1,890	17,967	66	1,494	305	208,025	*Nil.*	38,265	2,056	1,097	165,135
1897....	1,634	17,351	182	1,652	403	370,195	*Nil.*	100,566	2,749	609	161,138
1898....	3,002	11,517	220	907	68	329,546	*Nil.*	102,228	2,358	235	190,787
1899....	4,356	11,340	137	2,049	747	(*c*)	102	104,974	2,622	422	145,548

(*a*) From official statistics, except for the United States and Colombia, for which direct reports have been received from the producers. (*b*) Includes Herzegovina. (*c*) Statistics not yet published. (*d*) Export returns. (*e*) Shipments as stated in British Diplomatic and Consular Reports, except for 1899, which are estimated.

THE PRODUCTION OF MANGANESE ORES IN FOREIGN COUNTRIES.

BY FRANK DRAKE.

Brazil.—Brazil is assuming a growing importance as a producer of high-grade manganese ores. At present the most important manganese deposits in the country are those of Miguel Burnier, in the State of Minas Geraes. These and other Brazilian deposits have recently been described in a very complete and interesting paper by Mr. Herbert Kilburn Scott,* from which the following abstract has been made:

The Miguel Burnier Deposits.—Miguel Burnier is situated on the Central Railway of Brazil, at a distance of about 490 km. from Rio Janeiro, and within the region known as the "Highlands of Brazil." The rocks here were formerly assigned to the Laurentian and Huronian periods, but recent evidence renders it possible that they may eventually prove to be Cambrian, or even Lower Silurian in age. The manganese deposits, whose outcrops are frequently on the summits of the hills, stretch eastward from Miguel Burnier in the direction of Ouro Preto, and also southward to Bocaina. Between Miguel Burnier and Ouro Preto work is carried on over a distance of about 5 miles. The manganese deposits occur interstratified with decomposed iron and manganese ores lying between limestone walls, which contain small proportions of iron and manganese. The succession of strata between these walls, from below upward, is as follows:

* *Journal of the Iron and Steel Institute*, Vol. I., 1900.

1. Impure Earthy Ores of Iron and Manganese, adjacent to the footwall limestone, and including a thin stratum of micaceous iron ore next to the manganese bed.

2. The Manganese Ore Bed, varying in thickness, but at some points being about 3 m. It is made up in great part of hard metallic looking mineral which shows bedding, and has, interstratified, some softer and hydrated ore. The harder ore has a slight tendency to lay in lenticular masses, but occasionally the ore masses itself into very hard irregular blocks. The proportion of the hard ore varies, but generally averages about 80% of the whole. The softer ore is very heavily charged with hygroscopic water, and is responsible for the somewhat high percentage of moisture that the Miguel Burnier ore shows in the rainy season. The hard ore is exceptionally pure, the small quantity of metalloids being mostly concentrated in the softer mineral.*

3. Iterbirite, or "Jacutinga," lying adjacent to the hanging wall and consisting of thin layers of fine quartz sand and micaceous iron ore in alternate bands.

There appears to be an intimate association between the manganese ore, and the Jacutinga and limestone. The entire mass of strata between the two limestone walls is essentially ore, consisting of oxides of iron and manganese mixed with quartz. The author advances the hypothesis that these ore strata are the result of the decomposition and leaching of rocks originally carbonates; and that the leaching of the earthy ores lying on the footwall limestone has been a recent process, while that of the Jacutinga beds was an ancient one, subsequent to which the Jacutinga beds and the limestones have been metamorphosed. The evidence appears to be inconclusive as to whether the leaching of the manganese stratum itself has been a recent process, as in the case of the earthy ores, or an ancient one, as in the case of the Jacutinga beds. This point is important, however, as bearing on the question as to the probable depth to which the leaching of the ore stratum has extended. If this leaching has been a recent process a relation between it and the present system of superficial drainage may be pre-indicated; and it might then be assumed that the leaching had extended to a comparatively slight depth, and that the attainment of this depth by mining operations, would show a change in the ore deposit. On the other hand, if the leaching was an ancient process, it must have been entirely independent of the present drainage conditions, and in this case it may be reasonably assumed that no material change will be found in the character of the ore at very deep levels. The present workings have reached a depth of 120 m. from the surface outcrop (which is some 420 m. above the stream in the adjacent valley) and thus far have not revealed any indication of material change in the manganese ore.

The manganese deposits of Miguel Burnier were discovered in 1888 by Mr. Henry Hargreaves, Chief Engineer of the Central Railway. In 1893, Mr. Carlos da Costa Wigg acquired some of the deposits and in 1894 he began the mining and export of the ore under the name of Usina Wigg. In 1897 another firm, Messrs. Airosa & Co., commenced work in the neighborhood, and in 1899 a Belgian com-

* The ores of Miguel Burnier are said by Prof. Antonio Olyntho, of the School of Mines at Ouro Preto, to be largely pyrolusite and manganite.

pany, La Société des Mines de Manganèse de Ouro Preto, commenced operations. The quantities of ore in metric tons exported during 1899 have been as follows:

Miguel Burnier.—Usina Wigg, 28,400; Airosa & Co., 34,000; La Société des Mines de Manganèse de Ouro Preto, 1,000; *Bahia:* Pedras Pretas Co., 4,992.

The Mines of the Usina Wigg.—In these mines the ore bed, as a rule, dips at from 40 to 60°, but occasionally is vertical. At the commencement of their exploitation the ore was obtained by open-cast workings, but after a time these became impracticable, and underground work was commenced. Levels are driven into the bed at about 30 m. vertical height between each, and of three sections, as follows: No. 1, 1·6×1·2 m.; No. 2, 2×1·5 m.; No. 3, 2×2 m.

The smallest size is used for the exploratory headings, which are continually found necessary in order to follow the deposit. The width of 1·2 m. just allows the passage of a small trolley on a 50-cm. gauge line. The timbers used for the sets in this smallest level need not be of good quality and consequently rejected railway sleepers are used, with common 1-in. boards for lagging. As all these levels are afterward substituted, the sets are used repeatedly. The No. 2 size is used for less important permanent levels. It allows of a single trolley line, and space for the passage of workmen.

The No. 3, or largest size, is used for the main levels, and accommodates two lines of 20-in. gauge.

The smaller levels are always driven in ore, but the largest, owing to its size, occasionally requires the removal of rock, which is preferably taken from the footwall, as the hanging, especially when of friable Jacutinga, is dangerous. Native woods, brought from the interior by rail, are used for timbering the two larger sized levels.

At intervals of 40 m., rises are put up from one level to the other. In driving them the miner keeps close to the footwall, working as narrowly as possible, and after he has cut through into the next level, the rise is widened out and timbered. A piece of the bed about 4 m. in height is left immediately over the main levels and stoping is commenced from the top of it upward toward the next level. Every rise is furnished with a bin or pocket, which is constructed alongside the main road and has a capacity of about 20 tons of ore. It is provided with a suitable door, to enable the ore trolleys to be filled with regularity, a pass for the workmen and material being kept on the side of the bin. The size of the rises is 2 m. square. Iron chutes are placed in the rises and serve to bring down the ore from the stopes to the bin. In order to avoid any possibility of falls of the hanging wall a thickness of 50 cm. of the ore bed is left over the cap-piece of the rise timbering.

Stoping is commenced by putting in a small road on each side of the rise to meet similar ones from the other rises. These roads are of the smallest size, 1·6×1·2 m., and the sets are put in about 2 m. apart, the back only being lagged to prevent small falls. These small headings are driven on the footwall side of the bed, and a little of the footwall is mined, which releases the bed, and enables the miner to get the ore with greater facility. The roads from each rise meet about halfway, each miner working back, taking out the rest of the bed on the hanging-wall side and filling up the stopes as he proceeds. The filling is obtained

from between the bed and the footwall limestone by driving crosscuts of small section at right angles to the bed.

As falls occurred when the timber was taken out during the filling of the stope, it has now been decided to leave the timber in place, and as a recompense for its loss there will be greater security of the mine, and consequently greater efficiency of the miners. It has been found that the hanging wall is perfectly secure so long as the bed is not allowed to come away, so that the narrow timbering put in is enough to enable all the bed to be got and filled in without any danger to the men. After one piece of 1·6 m. high has been got, another one is started immediately above it, and the filling being soft, the set nearest the hanging wall is allowed to rest on the cap-piece of the set below. The ore is thrown into the chutes from the bed without any picking, this not being necessary. No water in any quantity is found in the workings.

The ore from the mine pockets is loaded into trolleys, and by mule traction, is taken to self-acting gravity inclines on which 2-ton trolleys are used for transmission to the storage platforms on the side of the railway. It is all shipped as mined, with the exception of some from one of the top levels that is passed over a grizzly at the bottom of a long chute. The workmen employed are Brazilians, Italians and Spaniards. The former, although good workmen, keep irregular time, their homes being in the surrounding villages, to which they are continually going for a holiday. The Italians and Spaniards, being foreigners, work with more regularity. The working day is divided into two shifts of 12 hours, with one hour in each shift for meals. The climate is exceptionally good, the mine being situated 4,000 ft. above the sea. The handling of the ore from the mouth of the different levels to the loading platforms is done at a fixed price per ton, but the getting of the ore has not yet been put on a piece-work basis, owing to the difficulty of fixing a uniform price. As a substitute the leading miners are paid a bonus in addition to their wages. The miners earn 4·5 milreis per day, and other hands 3·5 milreis, these latter only working 10 hours per day.

The Usina Wigg is supplied with a well-equipped laboratory which is systematically used in checking the mining work, and in determining the grade of shipments. Pattison's volumetric method of analysis is generally used, which has been found to give, with these ores, results agreeing remarkably well with those obtained by weighing the manganese as phosphate. The two complete analyses given below show the results of cargo samples of ore shipped by the Usina Wigg, the first at the commencement of the exploration and the second during the year 1899, and illustrate the remarkable uniformity of the ore.

ANALYSES OF MANGANESE ORE AT DIFFERENT TIMES.

Components.	February, 1895.	March, 1899.	Components.	February, 1895.	March, 1899.
	%	%		%	%
Silica	0·53	1·27	Arsenic acid	*Nil.*	0·034
Manganese peroxide	80·62	79·40	Carbonic acid	*Nil.*	*Nil.*
Manganese protoxide	5·47	6·23	Potash and soda	Trace.	0·55
Alumina	2·21	1·45	Combined water	4·95	4·74
Oxide of iron	2·50	4·03			
Baryta	2·30	1·90	Total	100·30	99·757
Lime	0·70	Trace.			
Magnesia	1·05	0·05	Manganese equivalent	55·14	55·02
Phosphoric acid	0·07	0·048	Phosphorus equivalent	0·030	0·021
Sulphuric acid	Trace.	0·065			

The amount of ore at present in sight, and available for mining without motive power, in the properties of the Usina Wigg, is estimated by the writer at 2,000,000 tons.

Airosa & Co.—The operations of this firm extend along the branch railway between Miguel Burnier and Ouro Preto. In 1895 this company leased mining rights in lands in this locality at a royalty of 4d. per ton (500 reis). It conducts both underground and open-cast workings and has a number of platforms on the railroad for storing the ore, as well as inclined planes for transportation. The analyses of cargoes of ore shipped by this firm give an average of about 50% Mn and 0·04% P, in ore dried at 212°F.; with from 10 to 20% H_2O.

The Central Railway of Brazil is broad gauge from Rio Janeiro to Lafayette, a distance of 450 km. From this point onward it is meter gauge, so that ore shipped from the mines near Miguel Burnier must be transferred at Lafayette. The ore is transported to Rio Janeiro in special mineral trains, and on arrival is loaded into hulks alongside the railway pier, and is there stored until it can be exported, or else it is unloaded on an island in the Bay. The railroad freight from the mines to Rio Janeiro is 5s. per ton (8·8 milreis). Ocean freights from Rio Janeiro to England vary between 10 and 20s. per ton.

Deposits between Miguel Burnier and Ouro Preto.—The Jacutinga iron-schist stratum continues to outcrop irregularly along both sides of the railway, on the branch line toward Ouro Preto, the same following the dip of the mountain, and it is in the vicinity of this that the manganese masses are found. The manganese occurs in this district in two distinct forms: 1. Crystallized. This ore, although not occurring generally with the Jacutinga, may be considered as derived from the denudation of the manganese bed that accompanies the Jacutinga, and subsequent recrystallization in the superficial clays. It is very rich in manganese peroxide, but is frequently high in iron, silica, and phosphorus. As yet it has not been found in any well-defined beds, restricting itself to comparatively small deposits over a large area. At grass it has a good appearance, owing to its interstices having been deprived by the weather of their earthy contents, but immediately below the surface it is generally found impure, and degenerates into a simple brecciform mass bound with limonite.

2. Hydrated Ores.—Manganese ores are often found acting as the binding material in conglomerate masses of broken down Jacutinga. Surface stuff, as in the crystallized ore, is good, but below the ore is siliceous in the highest degree. This hydrated ore often contains nickel and cobalt. These ores are the most recent, and are being formed at the present time by depositions from solutions coming from the manganese beds. Properties in this district showing both crystallized and hydrated ore have been exploited from time to time, but have generally been unremunerative, on account of either limited quantity, or the low quality of the ores.

Other Deposits in the Vicinity of Miguel Burnier.—At Bocaina, a little to the south, and at the Vegia and other properties around Burnier, manganese deposits are found, which are, however, limited as to quantity, and, in the main, of so low a quality as render them commercially valueless under present conditions.

Deposits in the Lafayette District.—The country around Lafayette is of altogether a different character, physically and geologically, from that of the Miguel Burnier and Ouro Preto district, the rocks restricting themselves to granite and mica schists, with complete absence of Jacutinga or other iron ore, and limestones. While in the Miguel Burnier vicinity the country is extremely rugged, in the Lafayette district it is only slightly undulating, with few eminences.

The manganese outcrops in the Lafayette district are contemporaneous deposits and their manganese content varies considerably. The absence of Jacutinga and the intermixture of much fine silica in the composition of the ores would point to their being of a different derivation from the deposits of Miguel Burnier. The Lafayette district is made up geologically of clays (formed by the decomposition of granites and schists) and undecomposed granites, and it is probable that the ore beds, which are composed largely of braunite, have been formed by the leaching out of the manganese from some siliceous rock like granite; the separation of manganese and silica being, for some reason or other, contemporaneous.

Several attempts have been made at the exploitation of deposits in the Lafayette district—notably at Barrosa, Morro da Mina and Pequiry. At the two former localities the ore was found to be too limited in quantity, or to contain too much silica or too much phosphorus, to permit profitable working. At Pequiry, which is about 8 miles westward from Lafayette, Airosa & Co. has made preparations for mining, and has constructed a narrow gauge railway to connect with the main line of the Central Railway. At present the loose weathered ore on surface is being exported, a sample of which has shown 51% Mn. This ore is, however, more siliceous and phosphoric than the better ores of Miguel Burnier, and it seems quite probable that, as soon as depth is attained, it will degenerate into the average Lafayette district braunite.

Besides the above localities, ore has been found at Sâo Gonçalo, about 6 km. from Pequiry and 10 km. from Lafayette, which from appearance, direction of strike, etc., may belong to the same bed as that of Pequiry. No exploration sufficient to show the commercial value of the Sâo Gonçalo ore has yet been made.*

Other localities in the State of Minas Geraes in which manganese ore exists, but of which little is known, are at Ilhéos, on the Veste de Minas Railway, at Renera and Gandarella, east of Ouro Preto, and in the vicinity of Bello Horisonte, the new capital of the State. Outside of the State of Minas Geraes the only manganese deposits at present productive are those at Nazareth, near Bahia, which were described in THE MINERAL INDUSTRY, Vol. VIII. Manganese ores are also known to exist in the States of Santa Catherina, Parana, Sâo Paulo and Matto Grosso, but little information regarding them is available.

Canada.—The mines at Tenny Cape, Nova Scotia, which have long been inoperative, are now claiming attention, due to the increased demand for manganese ores of good quality. At the Moseley mines in Cape Breton County, the

* Recently it has been reported that La Société des Mines de Manganèse de Ouro Preto is building a railway from Lafayette to Sâo Gonçalo, with the intention of working the manganese deposits at the latter place.

ore is found both in the crystalline and the amorphous form, in a red shale of the Lower Carboniferous age about 5 ft. thick, where it occurs in layers or beds varying in thickness from 1 to 18 in. The grade of the ores of these districts is indicated by the following analyses:

Components.	Tenny Cape Mines.		Moseley Mines.		
	%	%	%	%	%
Manganese oxides	84·6				
Manganese peroxide		90·15	91·84	87·64	92·65
Insoluble	17·2	2·80	2·71	8·51	Trace.
Phosphoric acid		1·029			
Ferrous oxide	0·603	2·55	0·12	Trace.	4·14

The completion of the railway between the Strait of Canso and Louisburg will furnish a ready access to excellent shipping facilities. A few tons of ore have been shipped from New Ross, in Lunenburg County, and the district is of promising importance. Huebnerite, a manganese tungstate, has been produced in some quantity from Emerald, in Inverness County.

Albert and King counties, New Brunswick, contain deposits of pyrolusite that are controlled by the Mineral Products Co., which is said to be contemplating the erection of a ferromanganese furnace.

Chile.—Manganese ores are mined in Coquimbo and Atacama, the respective shipping ports being Coquimbo and Carrizal. The ores average about 50% Mn, 10% SiO_2 and a little less than 0·1% P. The manganese ore exports of Chile during the last 10 years are estimated by the *Revista Commerciale Industrial de Minas,* of Santiago, at 344,087 tons, having a valuation of $12,145,179 (Chilean). Of this sum, $5,943,500 represents the cost of shipment to Europe, leaving $6,201,167 as profit to the producing country. The development of the manganese deposits was begun in 1884, with an output of 4,324 tons, and the product increased gradually until 1890, when 50,000 tons were produced. Since the latter year the annual output has reached as much as 51,000 tons, but has averaged considerably less than this. During 1899, 20,700 tons were shipped from Carrizal Bajo, and a total of 40,200 tons from the country, which was an increase of 19,720 tons over the previous year's shipments.

Cuba.—The exports of manganese ore to the United States in 1900 were 20,582 long tons, valued at $259,348, all of which was mined in the Santiago district. The deposits are located north and west of the City of Santiago, and are said to be found over an area of several hundred square miles. Ore occurs near Bayamo and Manzanillo and deposits have been denounced on Corallito Hill near Guisa, and at Las Negros between Santiago and Manzanillo. The Standard Manganese Mining Co. operates mines near Cristo, 11 miles north of Santiago. A railroad is now building to connect the mines with the Sabanilla and Maroto Railroad. The washed ore from this mine analyzes Mn 51 to 56%, SiO_2 4% or less and P 0·01%. The Ponopo Mining & Transportation Co.'s mines are situated 11 miles northeast of Cristo, near which place connection is made with the Sabanilla & Maroto Railroad by a branch line. The ore is a surface deposit and is associated with sandstone, jasper and clay. The cost of mining, washing and placing ore f. o. b. cars at the mine is stated to be about $2·26 per ton. Washed ore

analyses about Mn 49%, Fe 2% and SiO_2 6%. The Augusta Luiz manganese properties extend over an area of 1,000 hectares. They are operated by the Sierra Meastra Mining Co., which has a 20-ton washing plant near the mine. It is expected that with the establishment of stable government in Cuba, the mines will experience rapid and extensive development.

France.—The largest manganese producer of France is the mine of Las Cabesses, in the French Pyrenees, which produces annually about 5,000 tons of ore, averaging from 40 to 45% Mn. Before shipment, the ore, which is the carbonate, is calcined to drive off carbon dioxide, and its tenor is thus increased to from 50 to 56% Mn. The deposits are now worked by underground methods and are controlled by "Las Cabesses Manganese Mines, Ltd."

Greece.—The deposits at Cape Vani are actively worked by Mr. Serpieri, of Athens, and a company has commenced work at Andros, near Gavrion, on the western coast, for the mining of iron and manganese ores. The latter ore contains 52% Mn and 15% SiO_2, and is said to be free from other impurities. The manganese mines at Fourkovouni Point have been abandoned, and the interests involved are in litigation. The production of manganese ore in 1900 was 8,050 tons, valued at $45,170, against 17,600 tons, valued at $98,560 in 1899.

Portugal.—The output of manganese ore is derived from the mines at Freixal Ferragudo and Cerro das Camas Freixas. Stock speculations and the lack of proper transportation facilities, however, retard the development of the industry. The ore is said to be of high quality, but definite information regarding this, and its mode of occurrence, is lacking.

Russia.—The production of the Caucasian mines, from which the world draws its principal supply of manganese, has reflected the activity of steel manufacture during the past few years; in 1899 the shipments from these mines reached the total of 416,340 long tons. The Caucasian deposits have been fully described in previous volumes of THE MINERAL INDUSTRY, but the more important facts regarding them are briefly recapitulated below: The principal deposits are found near Chiaturi, a village of the district of Sharopan, in the Government of Koutais. The ore occurs in a bedded deposit, from 6 to 7 ft. thick, of great extent, and lying almost horizontally. The enclosing rock is a sandstone of Miocene age. The ore is largely pyrolusite mixed with other oxides, and, more or less, with sandy and calcareous material. It is estimated that the deposit will yield upward of 80,000,000 tons of marketable ore. The imperfectly sorted ore that is exported averages about 50% Mn and about 0·16% P, with less than 8% SiO_2.

Chiaturi is connected by a narrow gauge railway with the main line of the Trans-Caucasian Railway, and by this route the manganese product is shipped to Poti and Batum, on the Black Sea. Recently the narrow gauge road, which formerly terminated at Chiaturi, has been extended beyond the village to a place called Surmoot, which increases the shipping facilities of some portions of the ore field.

S. J. Vlasto* states that the ore field at Chiaturi is divided into about 5,000 claims, about 3,750 of which are controlled by 14 persons, who hold from 25 to

* *Engineering and Mining Journal*, Sept. 22, 1900.

500 claims each. The remaining 1,250 claims are held by about 300 peasants and small merchants. Mr. Vlasto gives the price at which ore, delivered at Chiaturi railway station, was sold at the beginning of the year 1900, as 6·5 copecks per pood, equivalent to $2·10 per long ton. Later in the year the increasing demand for export raised the price to the equivalent of $2·60 per long ton. The London quotation for Caucasian ore (which in 1897 was as low as 9 and 9·5d. per unit) has been advanced by the increasing demand to 12d. ($12·12 per ton for a 50% ore). In the United States the price has advanced to about 26c. per unit. Freight rates from Poti to the United States advanced from 14 and 16s., at the beginning, to 21 and 23s. and upward, toward the end of the year.

The facilities in all branches of the Caucasian ore industry have proved entirely inadequate for handling the large quantities of ore demanded of the mines during the last few years. The primitive methods of mining and sorting the ore, and of transport from the mines to Chiaturi railway station, the insufficient rolling stock on the railway, and the restricted facilities at the port of Poti, all militate against the development of the industry. To avoid the excessive detention of vessels that occurs at Poti, terminal facilities have been provided by some of the exporters, at Batum, and while the rail-haul and the port charges are greater, the gain in time more than offsets the additional expense.

Much complaint is made locally of the excessive freight charge levied on the ore by the Government Railway Administration, and several efforts have been made to get this reduced. It is not apparent, however, that the industry would benefit by such a reduction. If the freight was lowered competition between the producers would soon reduce the selling price to the extent of the reduction in freight, so that, as the sales of ore would not be materially increased, the result would merely be to transfer a certain part of the profit the railway now earns to the foreign consumers of the ore. There seems, therefore, little likelihood of any reduction in rail freight being made.

Besides the Caucasus product, manganese ore is produced in Russia in the Government of Ekaterinoslav, and in the Urals. Most of the ore of these localities is used locally, but occasionally a cargo from Ekaterinoslav Government is exported.

Spain.—Manganese ores proper are produced principally in the district of Huelva. The ores of this district are the carbonate and the silicate. They carry from 30 to 48% Mn, and are low in phosphorus. There are 23 mines in the district. In 1899 the exportation of carbonate ore was 148,119 tons; to this must be added 300 tons of oxides, containing about 50% Mn, which came from the provinces of Oveido and Teruel, making a total of 148,419 tons. Heavy taxation, difficult shipping conditions and lack of roads impede the progress of the industry. Manganese ores remain unaffected by the change in tariff that became operative March 19, 1900. In addition to the manganese ores, there are annually exported from the south of Spain about 400,000 tons of manganiferous iron ore.

MICA.

THE output of sheet mica increased in 1900, the large falling off in North Carolina being more than counterbalanced by the activity in the South Dakota mines. The total production was 127,241 lb. of sheet mica, valued at $82,508 and 5,417 short tons of scrap mica ($42,889). The consumption of mica has advanced very rapidly in the past three years, owing to the extensive utilization of the scrap product as an insulating medium for electrical apparatus, gas engines and in boiler and pipe coverings. In 1900 the imports were 1,892,000 lb. ($290,-872) unmanufactured mica and 64,391 lb. ($28,688) cut or trimmed mica, a total of 1,956,391 lb. ($319,560), while the corresponding figures for 1899 were 1,709,839 lb. ($233,446) and 67,293 lb. ($42,538), a total of 1,777,132 lb. ($275,984). In 1898 the total imports were 956,497 lb. ($150,082). The present import duty is 6c. per lb. upon unmanufactured and 12c. per lb. on cut or trimmed mica, with an additional 20% *ad valorem* duty upon each.

PRODUCTION OF MICA IN THE UNITED STATES.

State.	1899.				1900.			
	Sheet.		Scrap.		Sheet.		Scrap.	
	Pounds	Value.	Short Tons.	Value.	Pounds	Value.	Short Tons.	Value.
New Hampshire	9,000	$4,000	2,134	$19,206	25,241	$11,358	2,405	$21,645
North Carolina and Virginia	66,087	52,726	2,387	16,750	34,500	24,150	2,790	19,530
South Dakota	20,299	18,000	*Nil.*	*Nil.*	65,000	45,000	222	1,554
Other States	2,200	2,200	2,500	15,000	2,500	2,000	20	160
Totals	97,586	$76,926	6,917	$50,956	127,241	$82,508	5,417	$42,889

During the year the American Mica Co. was incorporated with a capital stock of $3,500,000 to take over the Sills Mica Co., of Chicago, Eugene Munsell & Co., of New York and the American Mica Co., of Boston, Mass. It is stated that options were secured on many of the smaller companies throughout the United States.

Idaho.—A deposit of mica has been discovered in Robinson's mining district, Latah County, about 18 miles from the Northern Pacific Railway. The mica occurs as more or less well developed crystals in a pegmatite dike which averages 6 ft. in width and has been traced along the outcrop for nearly a mile. The crystals are usually of abnormal size, one specimen measured 22×26 in. and

weighed 117 lb. Development has been carried to a depth of 60 ft. and a tunnel is now being run which will strike the deposits at a depth of 500 ft. In 1900 about 1,500 lb. of stove mica and 14 tons of rough crystals were mined.

Maine.—The Northern Mica Co. was organized with a capital of $250,000 to operate in Oxford County. The company controls leases on 12,000 acres of land supposed to contain deposits of mica.

New Hampshire.—The Newfound Mica Mining Co. opened a mine at Bristol, Grafton County. The dike carries feldspar, quartz, beryl and pyrites besides mica and has a width of 20 ft. A shaft has been sunk to a depth of 80 ft. from which levels are run along the strike. About 1,200 lb. of rough, fine quality mica were obtained per day which afforded 6% sheets ranging from 2×3 in. upward and 15 to 25% mica suitable for electrical purposes. The prices obtained for the sheets range from 35c. to $6 per lb., while the electrical brings 7·5 to 15c. per lb.

North Carolina.—There was no production of consequence from new mines in 1900 and the industry was mostly carried on by small operators. The Detroit Mica Mining Co. suspended operations in the early part of the year.

South Dakota.—The mines in the Black Hills made large shipments to the Chicago and New York markets. Most of the sheet mica was of small size, suitable only for electrical washers, segments, etc. The New York mine, near Custer, and the Lost Bonanza mine, of Deadwood, were the chief producers.

Argentina.—For several years past shipments of sheet mica have been made from Argentina to European countries. The mines are located in the mountainous part of the Province of Cordoba, a region made up of metamorphic and igneous rocks. Sheets are extracted which measure 70 cm. in length by 10 cm. in width, but usually they are from 7 cm. to 10 cm. long and of varying width. The sheets are only roughly trimmed at the mines, as cut mica is subject to a high import tax in most of the European countries.

Canada.—The output in 1900 was valued at $166,000. A deposit was opened near Kamloops, B. C., but did not reach the productive state.

German East Africa.—The discovery of mica is reported from the Uluguru Mountains, west of Dar-es-Salaam. It is thought that mining will prove remunerative in spite of the difficulties of transport as the material is of good quality and would command high prices.

India.—The production in 1899 was 630 metric tons, valued at $227,378.

MOLYBDENUM.

THE production of molybdenum and ferromolybdenum in the United States in 1900 amounted to 32,000 lb. and 11,000 lb., respectively. As in the previous year, the greater part of the ore supply came from New Mexico and Arizona. New deposits of molybdenite were discovered in the State of Washington, in Routt County, Colo., and at Las Vegas, N. M. Molybdite (MoO_3) has been found near Telluride, Colo., a similar occurrence to that at Pitkäranta, Finland. The ore carries from 2 to 16% molybdic acid, and exploration work has been commenced to determine the extent of the deposits.

For the determination of molybdenum in alloys, H. Bornträger* proposes the following method: About 1 g. of the alloy is dissolved in 50 c.c. of aqua regia on a water-bath, and the solution evaporated with hydrochloric acid. By treating the residue with 50% alcohol, and filtering, the greater part of the insoluble molybdic acid is obtained on the filter. The filtrate is evaporated, and the residue again treated with alcohol. The molybdic acid is collected on the tared filter, dried, and weighed; other metals present are determined in the united filtrates. A method employed by E. Döhler† involves solution of the alloy in nitric acid, evaporation, taking up the residue with hydrochloric acid and precipitation by hydrogen sulphide. The precipitate is filtered, washed with hydrogen sulphide water and transferred to the flask with hot ammonium sulphide. After boiling until hydrogen sulphide is entirely expelled, the solution is filtered and the precipitate dried at 120°C. A portion of the precipitate is then ignited in a current of oxygen until the weight is constant, and the molybdenum content is calculated from the weight of the molybdenum sulphide so determined.

* *Zeitschrift für Analytische Chemie*, Vol. XXXIX., 1900, p. 91. † *Chemiker Zeitung*, June 27, 1900.

NICKEL AND COBALT.

THE production of nickel and cobalt oxide from domestic ores in 1900 was 9,715 and 12,270 lb., respectively, all derived from Mine La Motte, Mo. No new discoveries of importance were made during the year; the occurrence of a large body of nickel-cobalt ore in the West was reported, but it proved upon examination too low grade for profitable working. Of mineralogical interest is the finding of sphærocobaltite ($CoCO_3$) in sandstone from La Sal Mountains, Utah, the only known occurrence of this mineral in the United States.

The market for nickel was firm throughout the year. In January the bottom price for large orders was 40c. per lb., while 45c. was asked for small lots, these prices being 5c. in advance of the quotations at the beginning of 1899. As the demand continued brisk with decreasing supplies, prices were advanced in April and were maintained for the remainder of the year at 45@50c. according to size and terms of order.

UNITED STATES PRODUCTION, IMPORTS AND EXPORTS OF NICKEL.

Year.	Production.						Imports. (b)		Exports. (d)	
	From Domestic Ore		From Foreign Ore.							
	Metallic.		Ni in Sulphide, Oxide, etc. (a)		Metallic.					
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1896.....	17,170	$4,464	2,096,890	$419,378	1,600,049	$400,012	102,412	$32,532	2,756,604	$606,833
1897.....	33,700	11,668	1,459,390	505,241	2,640,000	913,968	177,392	53,013	4,255,558	997,391
1898.....	11,145	3,845	3,516,427	1,213,167	3,611,357	1,245,918	(c)	(c)	5,657,618	1,359,609
1899.....	22,500	8,156	3,003,122	1,088,632	5,045,221	1,828,893	(c)	(c)	5,004,377	1,151,923
1900.....	9,715	4,534	3,605,138	1,682,520	4,107,982	1,915,193	(c)	(c)	5,870,206	1,382,727

(a) The nickel reported as in oxide is now mostly converted into metal before consumption. (b) Includes nickel, nickel oxide, and alloys of any kind in which nickel is the chief element of value, but not manufactures, ore, or matte. (c) None reported; the imports of ore and matte amounted to 17,819 long tons ($1,020,932) in 1898; 19,687 long tons ($1,101,939) in 1899; and 25,670 long tons ($1,183,884) in 1900. (d) Comprises domestic nickel, nickel oxide, and matte.

UNITED STATES PRODUCTION AND IMPORTS OF COBALT OXIDE.

Year.	Production	Imports.		Year.	Production	Imports.	
	Pounds.	Pounds.	Value.		Pounds.	Pounds.	Value.
1895.....	6,400	36,155	$39,839	1898.....	9,640	33,731	$49,245
1896.....	12,825	27,189	36,212	1899.....	10,200	46,791	68,847
1897.....	19,300	24,771	34,773	1900.....	12,270	54,073	88,651

THE WORLD'S PRODUCTION OF NICKEL. (METRIC TONS.)

Year.	New Caledonia.				Canada. (*b*)	Norway.	United States.		World's Total.
	Prussia.	France.	England.	Total.			Domestic	Imported	
1895	698	1,545	305	2,548	1,764	17	5	1,220	4,334
1896	822	1,545	405	2,972	1,541	16	8	1,685	4,537
1897	898	1,245	715	2,858	1,813	*Nil.*	15	1,859	4,686
1898	1,108	1,540	960	3,608	2,503	*Nil.*	5	3,234	6,116
1899	1,105	1,740	1,000	3,845	2,605	(*a*)	10	3,651	7,506
1900	(*a*)	(*a*)	(*a*)	(*a*)	3,212	(*a*)	4	3,499	

(*a*) Statistics not yet reported. (*b*) Nickel in ore and matte, nearly all the Canadian nickel is refined in the United States.

NOTE.—The figures for France and Prussia are from official reports; the amount credited to England has been obtained by deducting the output in France from the combined output of the French and English works as given by the *Metallurgischegesellschaft, A. G.*, except in 1899, when the English production was reported separately. The actual output of all English works is somewhat greater than the above amounts as a little Canadian ore is smelted there. The Prussian figures include a small amount of nickel of domestic origin. The Canadian figures are those of the Geological Survey of the Dominion. The world's total has been arrived at by adding the production from New Caledonian ores, the output of Canada and Norway, and the domestic production of the United States. In 1899, however, the total represents the total output in the United States and the production from New Caledonia ores, since the imports into this country were not derived from Canada alone.

Canada.—According to the report of the Dominion Geological Survey, the production of nickel in Ontario in 1900 was 7,080,227 lb., valued at $3,327,707, against 5,744,000 lb., valued at $2,067,840 in 1899. The detailed statistics of Ontario compiled by A. Blue, Esq., director of the Ontario Bureau of Mines, are as follows:

Schedule.	1895.	1896.	1897.	1898.	1899.	1900.
Ore raised.....Short tons	75,439	109,097	93,155	123,920	203,118	216,695
Ore smelted.....Short tons	86,546	73,505	96,093	121,924	171,230	211,960
Per cent. nickel	2·67	2·67	2·08	2·28		1·67
Per cent. copper	2·73	2·54	2·86	3·43		1·59
Ordinary matte Short tons	12,525	9,733	13,706	21,101	19,109	23,336
Bessemerized matte..Short tons	103¼		328		106	112
Nickel content.....Short tons	2,315¼	1,948¼	1,999	2,284	2,872	3,540
Copper content.....Short tons	2,365¼	1,868	2,750	4,187	2,834	3,364
Cobalt content. Short tons						
Value of nickel	$404,861	$357,000	$359,651	$514,220	$526.104	$756,626
Value of copper	160,913	130,660	200,067	268.080	176,236	319,681
Value of cobalt						
Wages paid	209,960	247,151	253,223	315.501	443.879	728,946
Men employed	444	485	535	637	839	1,444

(By A. McCharles.)—"The nickel copper mines of the Sudbury district were developed to a remarkable extent during the year 1900. For several years previous to this time, the progress of mining on the entire nickel range had been confined mainly to the operations of one company, but with the advent of several new companies, notably the Mond Co., the Great Lakes Co., the Fischer-Neumann Co., and the Nickel Copper Co. of Ontario, Ltd., the progress of the industry became very active and is now on a satisfactory basis in every respect.

"The Mond Nickel Co. acquired 18 mining locations covering 2,900 acres in the Sudbury district. Its principal mine is at Victoria Mine in the township of Denison, about 25 miles southwest of Sudbury. The property comprises over 1,000 acres of mineral lands which contain a large deposit and several small ones. The mine produces 200 tons per day. The company has also purchased and opened up the Cryderman mine at Garson, 10 miles northeast of Sudbury. The smelting works are located at Victoria Mine station on the Sault Ste. Marie branch of the Canadian Pacific Railway, 11,000 ft. from the mine, and the ore

is conveyed thereto by a wire rope tramway. Under the supervision of Hiram W. Hixon, two blast furnaces each 44×120 in. section at tuyeres are being erected and two stands of Bessemer converters to concentrate the copper-nickel matte up to 80% previous to its shipment to Clydach, near Swansea, Wales, where refining works are under construction to treat the Sudbury matte by the Mond process. It is expected that the refining works when completed will produce from 1,000 to 1,500 tons of nickel and from 4,000 to 6,000 tons of copper sulphate per annum. The smelting plant is expected to be in operation in the spring of 1901 to be followed shortly by the refinery. The Mond Nickel Co. has secured an option upon the Levac mine and others on the basis of $120,000 and 25c. per ton royalty on ores until the owners shall have received $350,000. The ores are low grade, but occur in large bodies at shallow depths. A company was registered on September 20, 1900, under the title of the Mond Nickel Co., Ltd., with a share capital of £600,000 to take over from Dr. Mond the mining properties and plant as well as the patents relating to the Mond process and the refinery works at Clydach.

"The Canadian Copper Co. opened up several new mines and added three new furnaces to the smelting plant, making six in all which can smelt 800 tons of ore daily containing 4% of copper and nickel together. This corresponds to the production of 100 tons of copper-nickel matte. The company is also preparing to work one of the largest deposits of nickel-copper ore in the district, situated in the southeast corner of Snyder township, 7 miles from Copper Cliff near the Manitoulin & North Shore Railway. A mammoth rock house with three tracks and two Blake crushers is being erected at this mine.

"The Ontario Smelting Co. has built and equipped a concentrating plant at Copper Cliff to treat the ordinary matte of the Canadian Copper Co. so as to raise its nickel and copper content to 80% or more, before shipping it to the refinery of the Orford Copper Co. at Constable Hook, N. J. The Ontario Smelting Co. will also smelt ores from its mine near Massey station, now under development. It is a singular fact that in a country of innumerable lakes and rivers as that of the Sudbury district, nearly all of the mining and smelting companies have located their plants where it is difficult to obtain a water supply or a good dumping ground for the slag; the recently constructed refining plant of the Ontario Smelting Co. is no exception and water will have to be brought from some distance.

"The Great Lakes Copper Co. developed the Mount Nickel mine. The Lake Superior Power Co. is erecting a plant at the Gertrude mine in Creighton township to supply nickel ore to be used in the manufacture of ferro nickel and nickel steel at Sault Ste. Marie. The Nickel Copper Co. of Ontario, Ltd., is testing a property near Worthington station, where a small experimental plant has been erected for making matte by a new self-roasting process. This company is reported to have purchased a large group of mines in the North nickel range beyond the Vermillion River. In short, so many nickel properties have been purchased in the last two years that practically only enough mines are now left for one additional good sized company and it is very probable that even these will be purchased before the end of the coming season. The entire nickel belt

has been fully explored, but no new discoveries have been reported with the exception of the North Star mine in Snyder township."

New Caledonia.—The ores of New Caledonia have been classified by the miners according to their color, although the terms applied are not consistent and differ not only in different mines but in different quarries of the same mine. The most common ores are termed "green" and "chocolate." Mr. F. Danvers Power* gives the analysis of commercial ores as follows:

Components.	Green Ore.		Chocolate Ore.			
	1.	2.	3.	4.	5.	6 (soft).
SiO_2	35·55	36·24	35·25	34·78	35·80	20·57
NiO	48·38	44·94	46·30	43·79	43·54	15·56
MgO	5·02	8·75		2·75	2·65	0·81
Fe_2O_3	1·41	0·21	9·00	6·30	10·73	49·03
Al_2O_3	1·09	1·03				
Cr_2O_3	0·15		0·14			3·82
MnO					0·19	Trace.
H_2O	8·85	8·98	9·20	12·40	8·00	10·32
Total	100·45	100·15	99·89	100·02	100·91	100·11

While the nickel content of these ores in the rich state is very high, the miners blend the product so that a uniform tenor of 7·25% Ni will be present. This is found more economical than to separate the second grade ore. At first large quantities of these ores were smelted at Noumea, but the work was not satisfactory, judging from the pellets of matte that remained in the slags on the dump. Later the works removed to Thio, which is nearer the mines, but 750 kg. only of matte were produced when the treatment was abandoned and the raw material has since been shipped for the most part to Europe. The Société le Nickel and the Nickel Corporation, Ltd., practically control the entire nickel mining industry. A nickel smelting and refining works are to be established in the Newcastle district, New South Wales, and plans and specifications have been completed. The plant is under the control of the New Caledonia Nickel Syndicate, Ltd., and will probably constitute the largest industrial concern of the kind in Australia. The mines in New Caledonia up to the year 1900 were fully described in THE MINERAL INDUSTRY, Vol. VIII. According to the report of the Secretary of the British Iron Trade Association, on Iron and Steel, at the Paris Exposition of 1900, the cost of extracting the New Caledonian ore, averaging from 7 to 8% Ni, is estimated at 25 fr. per ton. The freight to Europe is about 40 fr. per ton of 7·5% Ni ore. Deducting 15% for moisture present leaves 6·75 kg. of metal per ton, which corresponds to a freight cost of 0·62 fr. per kg. of metal. If the metal were smelted at the mines the freight cost per kg. would not exceed 0·005 fr. By the annual treatment of 100,000 tons of 7% Ni ore, which would yield 7,000 tons of metal, Messrs. Vivian compute the cost as follows: Ore, 2d.; smelting charge, 3d.; freight, 0·32d.; insurance, 0·15d., and packing, 0·21d.; total, 5·68d. The nickel ore of New Caledonia has the following analysis: H_2O at 100°C., 10·66%; H_2O (combined), 8·92%; SiO_2, 40·90%; Al_2O_3, Fe_2O_3, 12·86%; CaO, 0·04%; MgO, 15·18%; H_2SO_4 (combined), 0·17%; MnO, 0·70%; CoO, 0·25%; Ni, 7·79%; O, 2·17%; total, 99·64%.

* A paper read before the Institution of Mining and Metallurgy, London, May 16, 1900.

During the first six months of 1900 the shipments of nickel ore from New Caledonia were 42,315 metric tons and of cobalt ore 745 metric tons.

EXPORTS OF NICKEL AND COBALT ORES FROM NEW CALEDONIA IN METRIC TONS.

	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Nickel ore	45,614	40,089	38,976	37,467	57,439	74,614	103,908
Cobalt ore	520	4,156	5,302	4,823	5,395	2,373	3,294
Cobalt matte	169	7	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*

Tasmania.—Mining operations have been carried on at Nickel Hill, north of the Heazlewood River by the Lord Brassey Nickel Co. which has found ore as nickel-iron-sulphide and the hydrated nickel carbonate, zaratite. The sulphide occurs as the mineral heazlewoodite, classified by Dana as related to pentlandite. The shaft at the top of the hill is 25 ft. deep and a tunnel has been driven 570 ft. The work accomplished so far has not established the existence of ore in remunerative quantities.

Technology and Chemistry.

Combining Glass with Nickel Steel.—La Société Anonyme de Commentry-Fourchambault, Paris, France, patented* nickel steels containing from 28 to 30% Ni and from 42 to 46% Ni, to be used in place of platinum where a stable connection is required between glass and a metal. The coefficient of expansion of these alloys is the same as that of glass and such combinations are not liable to fracture with change of temperature.

The Determination of Nickel in Its Ores.†—A. C. Langmuir separates the iron as ferric chloride by ether in the presence of hydrochloric acid. A brief summary of the method is as follows: 3 g. of the ore is decomposed with 15 c.c. nitric acid and 1 or 2 c.c. liquid bromine. The solution is converted to chloride, and copper, etc., separated by hydrogen sulphide. The iron is oxidized by nitric acid and precipitated as ferric hydrate by ammonia—the precipitate carrying some nickel. The filtrate is evaporated and the precipitate is dissolved in hydrochloric acid, boiled to a pasty consistency and rinsed in a separating funnel by hydrochloric acid, sp. gr. 1·10, with the addition of 40 c.c. ether. Agitation for five minutes dissolves the ferric chloride and the aqueous solution is drawn off to a second funnel and again treated with ether. The continued ether extractions are washed with a little hydrochloric acid. The aqueous solutions containing the nickel are treated with ammonia after the removal of the ether by boiling. The ammonium chloride is expelled by boiling with nitric acid and the bases converted to sulphates by excess of sulphuric acid. On adding excess of ammonia the solution is ready for the electrolytic deposition of nickel, best accomplished with a current of 1·2 amperes.

Colorimetric Determination of Nickel in Ores in New Zealand.—F. D. Power‡ gives the following general method of analysis: 1 g. ore is dissolved

* English Patent No. 20,661, Oct. 14, 1899.

† *Journal of the American Chemical Society*, February, 1900. ‡ *Ibid.*, February, 1900.

in hydrochloric acid and diluted, ammonium hydrate is added to precipitate iron, the solution is diluted to given bulk and an aliquot part, 100 c.c. taken, which is filtered into a white bottle and direct color comparison made with standard samples.

The standards are obtained from portions of average ore samples which have formed the basis of sales and have been analysed. It is presumed that ore from the same mine contains about the same proportion of other coloring substances. The standards are renewed from time to time as they become deeper in color from evaporation. Cobalt ore is treated in a similar manner: 2 or 3 g. of powdered ore are treated with hydrochloric acid and ammonium hydrate added, the solution diluted to known bulk, an aliquot portion filtered as in the case of nickel and the pink coloration compared with a standard.

The Determination of Copper and Nickel in Sulphide Ores.—The following method for the determination of copper and nickel in sulphide ores has been perfected and adopted by the chemists of the Canadian Copper Co. at Sudbury, Ontario. As described by T. Ulke* 1 g. of the finely pulverized ore is heated on a steam heated plate with 4 c.c. of 50% sulphuric acid until effervescence ceases; 5 or 10 c.c. nitric acid are then added and the mixture evaporated to dryness. The mass is treated with water and the solution filtered into a narrow beaker. After adding 10 drops of nitric acid the copper is precipitated electrolytically by using a current of from 2 to 3 amperes for each assay. The solution now free from copper is oxidized with hydrogen peroxide, heated to boiling, and the iron precipitated with an excess of ammonia. The precipitate is filtered out, dissolved in dilute sulphuric acid, reprecipitated with an excess of ammonia, and this process repeated, making in all three precipitations of iron with ammonia. The combined filtrates are evaporated to about 200 c.c. and placed in a flat-bottomed beaker of Bohemian glass with ground top and approximately 3 in. in diameter and 4 in. high. To this solution about 100 c.c. ammonia are added, and the nickel deposited electrolytically. The cathode employed is an irido-platinum cylinder while the anode is of pure iron wire. During the process of deposition the solution is kept at a temperature of about 65°C. When the precipitation is considered complete, a few drops of the solution are drawn off with a pipette and tested with a 50% mixture of equal parts of carbon bisulphate and potassium sulphide, called potassium-carbon-sulphide, which gives a temporary pink color if the solution still contains nickel.

Separation of Nickel and Cobalt.—F. Janda† separates nickel and cobalt by adding to a slightly acid solution an equal volume of glacial acetic acid, boiling and subsequently adding nitroso-*b*-naphthol in 50% acetic acid. Nickel is held in solution while cobalt is precipitated.

The Estimation of Nickel in Steel.—H. B.‡ describes a volumetric method for the estimation of nickel in steel, which is sufficiently rapid to furnish results while the metal is still in the furnace. The nickel is titrated in an ammoniacal solution with potassium cyanide, using a suspended precipitate of silver iodide as indicator. The titration may be effected in the presence of iron, but if the steel

* *Engineering and Mining Journal*, Sept. 15, 1900.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, June 9, 1900.

‡ *Iron and Coal Trades Review*, Dec. 7, 1900.

contains chromium, the presence of iron renders the end point uncertain. One grain of the sample is treated with a mixture of 10 c.c. of hydrochloric acid and 10 c.c. of hot water, and when the steel is mostly dissolved, 10 c.c. of nitric acid (1·20) are added. If the iron is not to be separated, the solution is cooled, and 3 grains of citric acid, two or three grains of ammonium sulphate, and enough dilute ammonia to render the solution faintly but distinctly alkaline, added. To the alkaline solution is added a 2 c.c. of a 2% solution of potassium iodide, and enough silver nitrate to make the solution distinctly turbid. The cyanide is run in from a burette until the turbidity just disappears. The end point is plainly visible when the titration is performed in comparative darkness with a strong beam of light directed through the liquid by means of a lens. If the iron is to be removed before titration, the solution of the steel in dilute hydrochloric and nitric acids is partially neutralized with ammonia in a graduated flask, a slight excess of standard potassium cyanide run in from the burette, and the mixture rendered slightly alkaline with ammonia. The mixture is diluted to 500 c.c. and poured upon a large fluted filter. To 250 c.c. of the filtered solution are added 2 c.c. of the potassium iodide solution and a little ammonium sulphate, and the excess of cyanide titrated back with silver nitrate, the end point being marked by a slight turbidity. One c.c. of a solution containing 5·79 grains of silver nitrate per liter is equivalent to 0·001 grain of nickel. By this method an estimation of nickel can be made in 10 minutes.

R. Fieber* determines nickel in steel colorimetrically as follows: The sample is dissolved in nitric acid and the iron precipitated by ammonia. The degree of intensity of the blue coloration in the filtrate is proportional to the percentage of nickel present. Standard solutions differing from each other by 1% Ni are prepared for comparison. Chromium in relatively large percentages interferes with the results and the method is not applicable to steel less than 1% Ni.

F. Ibbotson and H. Brearley† discuss the separation of nickel and iron with ammonia and show the reasons for variations in the results of different methods of analysis.

Electrolyzing Nickel-Copper Matte.—(By T. Ulke.)—The electrolytic processes for treating nickel-copper matte may be classified into two general groups, according as they involve the electro-deposition of nickel and copper from solutions of their sulphates, or the deposition of these metals from solutions of their chlorides. To the latter group belong the processes invented by the late Dr. Carl Hoepfner and Mr. Hans A. Frasch.

The Hoepfner Electrolytic Process for Extracting Nickel and Copper.—As applied to copper-nickel matte and described in the English Patent No. 13,336 of July 8, 1893, granted to Carl Hoepfner, it relates to the preparation by electrolysis of nickel, cobalt, copper and chlorine. The cathode is immersed in a solution of the metal, which is either neutral or is mixed with weak acid, such as citric or phosphoric acid, and is arranged either to rotate as vertical metallic discs on a horizontal axis above the level of the liquid or to vibrate. The electrolyte surrounding the anode may alternately be raised and lowered in its level by means of a pump, etc. The anode is immersed in chloride solution of

* *Chemiker Zeitung*, May 9, 1900. † *Chemical News*, April 27, 1900.

one or more metals which are more electro-positive than the metal to be deposited. The anodes and cathodes are arranged in series, so that each anode cell is between two cathode cells. The anodes are kept regular by means of brushes, etc. Separating the anode and cathode compartments are diaphragms formed of nitrated cotton or linen, strengthened if necessary by asbestos on the cathode side, and in some cases also by a grate or sieve of wood, stone, glass or the like. When electro-depositing copper, the solution employed in the cathode compartments is cuprous chloride. The chlorine evolved from the anode cell is collected. The cuprous chloride may be prepared by the electrolytic treatment of cupric chloride solutions mixed with solvents of cuprous chloride as common salt; or by treating cupric chloride solution containing common salt or the like, with metallic coper.

The Frasch Electrolytic Process for Extracting Nickel and Copper.—As described in the *Engineering and Mining Journal* of September 8, 1900, and applied to copper-nickel matte, it consists essentially in the electrolysis of a brine solution so as to produce sodium hydrate at the cathodes of a divided cell, and chlorine in the anode section, which contains the matte, the metals in the matte being dissolved and forming chlorides. The solution containing the chloride is directly treated for the contained metals by electrolysis or chemical methods. (It has been suggested to remove electrolytically one-half the copper content of the solution, corresponding to the conversion of the cuprous salt to the cupric salt, and then to apply it to the extraction of the metals from the raw matte in which case the copper chloride solution being in the cupric condition would act chemically as a solvent for the metals in the matte and would reform the electrolyte solution suitable for further electrolysis. In practice, however, this has not been found practicable.)

The copper in the solution is recovered by electrolytic deposition, the nickel being separated from the cobalt and other metals as well as from remaining traces of copper as a chemical salt by a method described in United States Patent No. 668,899. In the article above referred to, Dr. Joseph Struthers states that the matte is submitted to a coarse crushing and is then conveyed to the vats where it is charged directly on a layer of carbonaceous material that forms the anode section at the bottom. On this layer of matte is placed a thin layer of sand, which gives a very satisfactory diaphragm for the separation of the resultant solutions of caustic soda and the chlorides of the metals. The vat is then filled with a salt solution which is electrolyzed and the metallic solution obtained at the anode as well as the alkaline solution at the cathode are periodically displaced by fresh salt solution. The passing of the two solutions from the reservoirs to and through their respective anode and cathode sections of the vats and thence to receiving tanks, is accomplished mainly by gravity. The subsequent handling of the solid material which remains in the anode section after treatment, consists of the removal of the upper layer of sand, which can be washed and used again, followed by the removal of the leached material, from which perhaps it might prove economical to extract the sulphur. Caustic soda is of course obtained as a valuable by-product.

OCHER AND IRON OXIDE PIGMENTS.

THE production of all mineral paints, including ocher, umber, sienna and iron oxide in 1900 was 41,917 short tons, valued nominally at $461,087, against 42,286 tons ($465,146) in 1899, while the imports were respectively 10,974,544 lb. and 12,284,708 lb. The production of Venetian and Indian red was 6,352 short tons ($110,658) in 1900, and 6,575 tons ($125,519) in 1899. The leading States in the production of ocher are Georgia, California and Vermont, while iron oxide comes largely from New York, Pennsylvania and Tennessee. Umber and sienna are produced in Missouri, Pennsylvania and New York. Under Venetian and Indian red is included only the pigment made by calcination of copper. The chief producers are the American Steel & Wire Co. at Waukegan, Ill., and Worcester, Mass.; C. K. Williams & Co., Allentown, Pa.; S. P. Wetherill & Co., Philadelphia, Pa.; and Mepham & Klein, St. Louis, Mo.

IMPORTS OF OCHER, UMBER AND SIENNA INTO THE UNITED STATES.

Year.	Ocher of All Kinds.						Umber. (b)		Sienna.			
	Dry.		Ground in Oil.		Total.				Dry.		Ground in Oil.	
	Pounds.	Value.	Pounds	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds	Value.
1896	8,954,252	$68,196	27,023	$1,561	8,981,275	$69,757	689,075	$8,360	(c)	(c)	(c)	(c)
1897	a 7,720,075	59,272	20,123	1,000	7,740,198	60,272	1,447,889	14,479	580,468	$12,340	7,058	$481
1898	5,898,720	46,571	31,460	1,546	5,930,180	48,117	1,123,079	9,051	544,713	11,451	4,008	280
1899	9,765,616	72,825	14,881	756	9,780,497	73,581	1,739,036	13,336	758,691	14,242	6,484	492
1900	8,449,252	57,342	19,167	1,019	8,468,419	58,361	1,703,256	11,862	796,534	14,912	6,335	495

(a) Includes 241,452 lb. entered as crude and 1,416,587 lb. as powdered. (b) In 1896 includes 5,292 lb. ground in oil and 683,783 lb. dry; in 1897, 14,471 lb. ground in oil and 1,433,418 lb. dry, crude or powdered; in 1898, 4,608 lb. ($323) ground in oil and 1,118,471 lb. ($8,728) crude, powdered, washed or pulverized; in 1899, 4,849 lb. ($300) ground in oil and 1,734,187 lb. ($13,036) dry crude, powdered, washed or pulverized; in 1900, 11,653 lb. ($723) ground in oil, and 1,691,603 lb. ($11,139) dry crude, powdered, washed or pulverized. (c) None reported.

The domestic mineral paint business in 1900 suffered from the high and fluctuating prices of linseed oil that prevailed during the spring and summer months. As a consequence the consumption did not reach normal proportions, and both manufacturers and dealers closed the year with unsold stocks. The import trade was also less active, although the imports exceeded in volume those of 1897 and 1898.

PETROLEUM.

THE chief features marking the world's petroleum industry in the year 1900 were the great extension of area brought under the drill, and the large increase in output from the American, Russian and other fields in the Far East. From a local point of view, the consolidation of Russian interests in the United Kingdom, the prominence into which the Roumanian oil fields have been brought by the efforts made by the Standard Oil Co. to obtain large concessions from the Government, and the great development of the Borneo oil fields, have been among the most important items. Looking at the matter from a competitive point of view, the incursion of Russian oil into various markets, especially into that of United Kingdom, has been the most conspicuous movement, although this has been offset by the great progress made by America in the Far East.

The prediction made in Vol. VIII. of THE MINERAL INDUSTRY that the year 1900 would show a large increase in the production has been fully justified. The output reached a total of 62,538,544 bbl., the largest amount yet recorded. Important gains were made in California and in the Appalachian and Lima fields.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES. (BARRELS OF 42 GAL.)

Year.	Appalachian Field. (a)	California. (b)	Colorado.	Indiana. (Lima Field.) (c)	Kansas.	Ohio. (Lima Field.)	Texas. (e)	Wyoming.	Other States.	Total.
1896.....	33,980,571	1,257,780	400,000	4,659,290	113,000	20,354,000	None.	2,878	3,600	60,771,119
1897.....	35,249,700	1,911,569	650,000	4,353,138	(c)90,000	18,507,000	65,000	15,000	(d) 8,000	60,849,407
1898.....	31,625,360	2,249,088	650,000	3,751,307	88,000	16,578,000	544,620	3,500	(d) 10,000	55,499,875
1899.....	32,870,689	2,677,875	600,000	3,818,713	(c)69,556	16,565,092	601,308	6,071	(d) 25,000	57,234,304
1900.....	35,540,965	4,250,000	525,000	4,912,675	(d)65,000	16,407,704	800,000	7,200	(d) 30,000	62,538,544

(a) Includes New York, Pennsylvania, West Virginia, and part of Ohio. The statistics of production in this field and the Lima field in Ohio as given in previous volumes of THE MINERAL INDUSTRY were based on the pipeline receipts reported by the *Oil City Derrick*. They have been changed in the present volume so as to represent the actual production. (b) Statistics of California State Mining Bureau. (c) Statistics of State Geological Survey. (d) Estimated. (e) The statistics for 1899 and 1900 were furnished by Mr. C. F. Z. Caracristi.

The total quantity of oil remaining in the hand of the pipe line companies at the end of the year shows in the aggregate a larger accumulation over that at the end of 1899. In the Pennsylvania district the stocks on hand showed little fluctuation during the year, though compared with the previous years there is a very distinct tendency to greater conservation. In Ohio and Indiana, a reverse tendency is shown over a series of years; in 1897 the stocks on hand

totalled never less than 22,000,000 bbl., in 1900 they have sunk to a little over 10,500,000 bbl., closing the year at about 14,500,000 bbl.

A general idea of the stocks on hand at the end of the year in the different districts may be gained from the following table in which the amounts are expressed in barrels of 42 gal.:

Appalachian.				Lima.			
1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
10,789,652	11,541,753	13,451,191	13,147,717	22,762,779	15,180,892	10,345,927	14,988,928

The average prices of petroleum in the Appalachian and Lima fields are given below:

MONTHLY AND YEARLY AVERAGE PRICE OF PIPE-LINE CERTIFICATES PER BARREL OF CRUDE PETROLEUM AT THE WELLS IN THE APPALACHIAN FIELD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Aver'ge
1896...	$1·45¼	$1·39	$1·33½	$1·22⅝	$1·10⅛	$1·14⅛	$1·09½	$1·05	$1·12⅝	$1·15½	$1·15½	$0·97⅞	$1·19
1897...	0·88	0·90½	0·92½	0·85⅞	0·85⅛	0·86½	0·76⅛	0·71	0·69⅛	0·67⅝	0·65	0·65	0·78⅛
1898...	0·65	0·67⅛	0·78⅛	0·73⅛	0·82½	0·87⅛	0·93½	0·97⅛	1·01⅜	1·13¼	1·16⅛	1·17½	0·91½
1899...	1·17	1·15	1·13	1·13	1·13	1·13½	1·22½	1·27½	1·44⅛	1·50⅞	1·57⅛	1·65½	1·29⅛
1900...	1·66⅜	1·68	1·68	1·55	1·39⅜	1·25⅛	1·25⅝	1·25½	1·23	1·10⅜	1·06¼	1·08¼	1·35½

AVERAGE MONTHLY PRICES OF CRUDE OIL IN THE LIMA FIELDS. (*a*)

Month.	1897.			1898.			1899.			1900.		
	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana
January...	$0·58	$0·53	$0·53	$0·46	$0·41	$0·41	$0·80	$0·75	$0·75	$1·19¼	$1·14¼	$1·14¼
February				0·50	0·45	0·45	0·80	0·75	0·75	1·24½	1·19½	1·19½
March.....	0·57	0·52	0·52	0·58	0·53	0·53	0·79	0·74	0·74	1·26	1·21	1·21
April.....	0·51¼	0·47⅛	0·47¼	0·54½	0·49½	0·49½	0·79	0·74	0·74	1·19	1·14	1·14
May.....	0·51	0·46	0·46	0·59	0·54	0·54	0·81⅜	0·76⅜	0·76⅜	1·08	1·03	1·03
June.....	0·49	0·44	0·44	0·64½	0·59½	0·59½	0·85½	0·80⅛	0·80⅛	0·95½	0·90½	0·90½
July.....	0·48	0·43	0·43	0·67½	0·62½	0 62½	0·90⅛	0·85⅛	0·85⅛	0·95	0·90	0·90
August....	0·47	0·42	0·42	0·71⅜	0·66⅜	0·66⅜	0·93⅛	0·88⅛	0·88⅛	0·93½	0·88½	0·88½
September							1·03¼	0·98¼	0·98¼	0·91⅜	0·86⅜	0·86⅜
October...	0·46	0·41	0·41	0·76	0·71	0·71	1·07⅜	1·02⅜	1·02⅜	0·82½	0·77½	0·77½
November.				0·77	0·72	0·72	1·11⅛	1·06⅛	1·06⅛	0·80	0·75	0·75
December.				0·79	0·74	0·74	1·16½	1·11½	1·11⅛	0·87	0·82	0·82
Average...	$0·51⅛	$0·46⅛	$0·46⅛	$0·63⅜	$0·58⅜	$0·58⅜	$0·92½	$0·87½	$0·67½	$1·01½	$0·96¼	$0·96¼

(*a*) Based on reports of the *Oil City Derrick*, except the figures for 1899 and 1900, which are taken from *Stowell's Petroleum Reporter*.

The exports of mineral oils from the United States during 1900 were far in excess of the previous year. The figures for the last five years are as follows:

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (IN GALLONS.)

(1 = 1,000 in quantities and values.) (*a*)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine.		Residuum.		Totals.	
1896.....	118,133	$6,032	13,641	$1,123	758,076	$49,704	51,705	$6,770	521	$28	942,076	$63,657
1897.....	121,864	5,044	13,704	1,020	804,446	46,876	52,659	6,732	12,247	335	1,004,920	60,007
1898.....	120,436	5,016	17,757	1,071	764,823	38,895	65,526	7,626	30,436	815	998,478	53,423
1899.....	118,690	5,958	18,210	1,597	733,393	49,173	71,105	8,656	21,609	658	962,007	66,042
1900.....	138,165	7,341	18,570	1,681	739,163	54,693	71,207	9,933	19,750	845	986,857	74,493

(*a*) In addition to the above, the following quantities of paraffine and paraffine wax were exported: 1896, 112,517 lb. ($4,563); 1897, 136,069 lb. ($5,284); 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186).

As will be noticed from this table, the exports of illuminating oil show a slight decline on the year, while the shipment of crude has considerably increased, and the same may be said to a lesser extent of naphthas; lubricating and paraffine, as well as residuum, on the other hand, show slight declines on the year.

Of this quantity 157,570,000 gal. were sent to the United Kingdom, compared with 166,194,455 gal. for the preceding year, showing a marked decline. The United States, however, has been pressing its products successfully in other directions, particularly in the markets of the Far East. According to statements which are published by Lane & MacAndrew, of London, American oil has been very successful in advancing against its competitor, Russian oil. From the statistics published by this firm in regard to the Eastern trade, the following condition of things is shown: The chief markets where American oil has made headway are those of China and Japan, where Russian oil has shown a very marked decline. And while in the Indian trade both countries register a falling off, that for America is small compared with that for Russia. At the end of the first six months of the year 1900, America had recorded an increase of over 1,500,000 cases, and Russia a depreciation to the extent of nearly 2,000,000 cases, for the whole of the Eastern trade.

OUTPUT OF THE PRINCIPAL PETROLEUM-PRODUCING COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Austria.	Hungary.	Canada.	Germany	India.	Italy.	Japan.	Russia.	United States.
1895.....	188,634	2,085	101,587	17,051	52,032	3,594	(*b*)22,463	7,056,330	7,413,914
1896.....	262,356	2,168	101,682	20,395	60,228	2,524	31,414	7,105,768	8,502,187
1897.....	275,204	2,299	99,310	23,303	76,834	1,932	35,325	7,831,254	8,513,140
1898.....	330,000	2,471	98,044	25,789	71,627	2,015	125,000	7,841,671	7,764,713
1899.....	309,500	2,125	113,718	26,700	106,000	2,242	250,000	8,470,925	7,926,400

(*a*) From the official reports of the respective countries. This table is only partially complete since it does not include the production of Roumania, Sumatra, Borneo, Java, South Africa, Peru, and some other countries.
(*b*) Estimated from hectoliters.

THE WORLD'S PRODUCTION OF PETROLEUM.

BY P. DVORKOVITZ.

IN regard to the general application of petroleum, the year 1900 is chiefly specialized by the increasing extent to which liquid fuel has been used for marine and other purposes. The most noteworthy example has been the trip of the Shell Transport and Trading Co.'s oil-tanker, the s.s. "Cowrie," which made the voyage from Borneo to London, a distance of nearly 10,000 miles, entirely on liquid fuel. Compared with coal the consumption was stated to have been about 26 tons per day, equivalent to from 30 to 32 tons of Welsh coal. During the year there were launched several ships adapted to the burning of liquid fuel, and in various parts of America, especially in California, as well as in Russia, liquid fuel has been largely adopted for industrial purposes. Among the new burners for liquid fuel which have been introduced during the year was one by Mr. Orde, chief engineer of W. G. Armstrong, Whitworth & Co. The principal feature of his method of burning oil is that of pre-heating it. The oil is supplied to the burner by a pump. The other important characteristics of this

system is that of pre-heating the air necessary for complete combustion, and transmitting it into the furnace in such a manner that perfect combustion of the oil vapors formed is ensured. This invention has been introduced in several steamships, including a number in the passenger trade.

The system adopted on Dutch steamers differs from other methods in that compressed air is used for spraying the oil into the furnace, instead of steam. The fuel oil is drawn through filters from the supply and is pumped direct to the burners, a constant pressure of about 25 lb. per sq. in. being maintained by means of a pump. The oil is heated in a small steam coil, and is maintained at a constant temperature (about 90° C.) in order to make the oil freely ignite.

It has been found from experiment that the best temperature for crude Borneo oil is 90° C.

Oil fuel is carried in the ship's double bottom, and sufficient is taken for a round trip of 6,000 miles. The whole apparatus, pumps, filters, etc., are duplicated, and the pump line is arranged from pump to burners to allow a quantity to be pumped through, so that at starting a supply of warm oil is provided for the burners.

Among the contributions on the subject, is a paper by Mr. Orde, read before the North of England Institution of Mining and Mechanical Engineers. The general conclusions deduced from his investigations are as follows: (1) Liquid fuel of good quality, as for instance, Borneo oil, used in boiler furnaces, if efficiently treated, should show a reduction in consumption of about 40%, compared with coal; (2) a reduction in bunker space of about 15% for the same weight of fuel; a reduction of about 50% for the same radius of action; (3) a reduction in the stokehole staff of at least 50%. In addition to these advantages, are others, such as ease of manipulation, cleanliness, absence of smoke, reduced temperature of stokehold, as compared with coal; increased life of boilers owing to constant temperature, and improved performance of engines owing to constant steam pressure.

Perhaps one of the most important movements, affecting the whole of the petroleum industry throughout the world from a scientific point of view has been the organization of the first International Petroleum Congress, held during the progress of the Paris Exhibition, 1900. At this congress representatives from Austria, Canada, England, France, Germany, Holland, Italy, Japan, Roumania, Russia and the United States were present and took part in the discussion of a number of highly valuable, scientific papers among which were the following: "The Desirability of Recording the Depth of Wells in Relation to the Sea Level;" "The Desirability of Introducing a Standard Method of Examining Petroleum and its Products for Technical and Commercial Purposes," by Dr. Boverton Redwood; "Various Methods of Deep Boring," by Albert Fauck; "The Canadian Petroleum Industry," by R. D. Noble; "The Examination of American Petroleums," by Prof. Mabery; "Solid Hydrocarbons in Petroleum Residuals," by Prof. Zaloziecki; "The Preparation of Lubricating Oils by Means of Concentration," by Mr. Berg; "The Utilization of Petroleum Products for Preserving Timber," by A. Adiassevich; "On Borneo Oil," by Paul Dvorkovitz; "On the Variation in the Character of Pennsylvania and Ohio

Crude Oils, and Causes Thereof," by Dr. David T. Day (Chief of Division of Mineral Resources of U. S. Geological Survey); "The Classification of Petroleum Products and the Standard Methods of Investigating Petroleum," by K. Charitschkoff; "The Origin of Petroleum," by Prof. Engler; "The Geology of Petroleum," by Prof. H. Hoeffer; "On Russian Petroleums," by Prof. Markovinovkoff; "On the Use of Oil with Lignite as Fuel in Roumania," by R. Sorge; "The Petroleum Motor for Aërial Navigation," by M. Henri Deutsch; "The Chemistry of Japanese Petroleums," by Prof. S. Takano; "Roumanian Petroleum," by M. C. Alimanestiano and Dr. L. Edeleano, and on the same subject by M. N. Coucou; "The Geological Investigation of the Oran Oil Basin," by Henri Neuburger.

These papers with discussions thereon were published by *The Petroleum Review*, of London, as special supplements.

North America.—The most striking features of the industry were the great activity among oil producers and the general prosperity of the trade. These are illustrated in the large output, general high prices, and profits of the various oil companies. The Standard Oil Co. disbursed $47,800,000 among its shareholders during the year. According to report this company controls 82% of the production of standard white illuminating oil.

California.—The Californian industry has been marked by a considerable amount of vitality during the year 1900, the producing territory being greatly extended, and the number of wells drilled having largely increased. The importance of these fields has been very practically proved by the action of the Standard Oil Co., in setting up storage tanks and other facilities in the midst of the field for dealing with the oil. The Californian oil differs from that of Pennsylvania and Ohio, its residuum being asphaltum, instead of paraffine; this quality making the oil very valuable for manufacturing varnishes, lubricants, etc. It has also a special use for fuel; the railroads in the oil districts are already important consumers, and on some of the large systems locomotives have been fitted up to burn crude oil. One line has made a contract with oil operators which calls for 750,000 bbl. per year for the next five years.

Production in 1900 was limited to the fields that were active during the preceding year, the only new development reported being the discovery of paraffine oil in Maine County, north of San Francisco. Los Angeles County still holds its position as the largest producer, although its importance to the other fields is gradually declining. The Kern River district was actively developed during the year and is now one of the most promising of the new fields.

The condition of the petroleum industry in California is set forth in the subjoined table:

District.	Wells Being Drilled.	Daily Production.	No. of Producing Wells.	District.	Wells Being Drilled.	Daily Production.	No of Producing Wells.
		Barrels.				Barrels.	
Coalinga.....	21	1,851	36	Ventura.....	60	2,177	314
Kern River.....	76	2,000	131	Santa Barbara....	17	808	303
Mt. Kittrick.....	32	966	34	Kreyenhagen.	40		17
Los Angeles	128	6,054	973	Sunset.....			39
South Los Angeles	33	2,978	145	Total.....	407	16,834	1,992

Reference should be made to the special monograph on "The Origin and Occurrence of Petroleum in California," by A. S. Cooper, which appears later in this section.

Ohio.—Development of the old fields was vigorously prosecuted throughout the year. In the Lima district, the records show that 5,129 wells were completed, giving an average daily production of 80,725 bbl. The average yield per well for the entire State ranged from 11·25 to 18 bbl.

Pennsylvania.—In one or two instances, the average monthly production in the Pennsylvanian fields has risen to a higher figure than any reached in the previous year; this was due, to a great extent, to the striking of the now historic Copley gusher, and to its neighbor, the Turner gusher, which had for some weeks a very large output, the former starting at about 6,000 bbl. per day. This prolific output, however, was not maintained, and the increase of production was, therefore, only of a temporary character. The average output of the wells in 1900 was from 15 to 23·25 bbl. per day.

Tennessee.—The oil production of the Obey River field, in Fentress County, during 1900, has been confined to two wells. The first in importance is the Bob's Bar well, owned by the Standard Oil Co., now four years old, with a production which, up to the present time, amounts approximately to 30,000 bbl. of petroleum. The well is remarkably steady and yields uniformly 22 bbl. a day throughout the year. The oil, which is found at a depth of 297 ft. below the surface, is dark green in color by direct light, and slightly amber in a reflected light. Its specific gravity is 41·6. A well recently drilled about 700 ft. to the northeast of the Bob's Bar well, on an equal surface level, at a depth of 350 ft. yields daily about 56 gal. of good quality amber oil. It is reported that the Standard Oil Co. will build a pipe line from its oil fields near Slick Fork, Ky., a distance of 20 miles, to their fields in Fentress County.

Texas.—During the year 1900 the development of petroleum lands in the Corsicana field has made considerable progress, although the supply has not yet exceeded the local demand. The Corsicana field, which is the chief producing territory in the State, covers an area of about 10 sq. m., and is being worked by quite a number of large companies, the pioneer of which was the Corsicana Development Co. The field operations appear to have been attended with varying results; thus, the returns for the month of October, 1900, show only 18 new producers and 7 gushers, which is considerably less favorable than the figures for previous periods. The oil from the Corsicana field resembles the Lima oil, but does not possess the disagreeable odor of the latter; it seems to be closely related to the Pennsylvania oil of the Washington district and contains substances closely resembling asphaltum, as it yields a precipitate with $SnCl_4$. Its sp. gr. is 0·829. The Nacogdoches oil is black and is strongly impregnated with hydrogen sulphide, resembling a maltha. Its sp. gr. is 0·915. Saratoga oil has a sp. gr. of 0·955 and that of Sour Lake 0·963, the heaviest American oil recorded. It leaves a residue of 71% when heated above 641°F. It contains no paraffine, but has 20% asphaltum and is well adapted to lubricating purposes. A pitchy mass was obtained from the oil resembling the distillation product of stearine. Outside of the Corsicana district the most noteworthy feature of the year was the dis-

covery of petroleum at Beaumont. A single well is said to have yielded several thousand barrels per day. If this section should prove productive, it will be an important factor in the industry as it is located near tidewater at a point where the oil can be easily handled and cheaply transported. Deposits, sometimes very prolific, are frequently being met with in the Texan fields, generally terminating in small oil producers. The total production of the State which in 1899 amounted to 601,308 bbl. reached 800,000 bbl. in the year 1900. The large Texan gusher was struck in January, 1901.

West Virginia.—The fields comprised in this State have during the year 1900 shown a particularly healthy condition, and they will very materially contribute to the total production of the Appalachian field. First and foremost stands Lewis County, by virtue of the Sand Fork development, which has by far been the most encouraging feature throughout the American fields during 1900. At the close of September, a strike was made at the Copley farm, Sand Fork, resulting in a spouter that started flowing at the rate of between 4,000 and 5,000 bbl. per day, and directly afterward attained 6,000 bbl. per day. It settled down later to about 3,000 bbl. per day, where it continued flowing for some time. Another prolific gusher was struck in the latter part of November, which yielded at the outset 250 bbl. per hour, but soon after settling down at about 2,400 bbl. per day. Since then it has constantly been declining simultaneously with the older gusher, and registering generally a little less. Wetzel County, Monongalia County and Beaver County have also been fairly successful in the matter of development; in the latter district interest has been centered around the Legionville pool, a little strip of land which has yielded through various wells a continued production of about 1,500 bbl. per day.

Wyoming.—The Superior Oil Co. with a capitalization of $10,500,000 has absorbed the Pennsylvania Oil Co., and has started development of this field on a large scale; 10 wells and a refinery at Caspar are in operation.

Canada.—The production in 1900 as in previous years came largely from the Petrolia district of Ontario. New wells were sunk in the Gaspé Basin and the construction of a refinery was undertaken by the Canadian Petroleum Co. From 1889 to the beginning of 1900 this company put down 33 wells in this region and in all but one oil was found. The life of the wells was short. The total output of oil in Canada in 1900 was 710,498 bbl., valued at $1,151,007.

Mexico.—The discovery of petroleum at Cuetzla, near Puebla is reported, and also the reopening of the Macuspana region by an European company.

South America.—*Argentina.*—A company was formed in 1900 for the exploitation of petroleum bearing lands. While deposits of petroleum have been known to exist for some time, they have hitherto only been developed in the most primitive manner. Prof. Blackebusch was sent to report on the petroliferous lands, and states that interspersed among the sandstones are lime and other rocks, and in many places petroleum drops from the crevices of the bituminous rocks.

Brazil.—According to J. C. Branner* the oil shales of the coast with one exception belong to the Tertiary age and the parti-colored beds exposed in the costal

* Read before the American Institute of Mining Engineers, August, 1900.

bluffs are for the most part the weathered portions of this series. The strata rest upon granites, gneisses and other crystalline rocks, with a bed of very coarse conglomerates at the base of the series. The exception noted occurs in the beds between the granites and the Cretaceous deposits that are in the Sierra d'Itabaiana, State of Sergipe, which appear to be of Paleozic age, although no fossils have been found in them. The total thickness of the Tertiary beds is from 100 to 300 ft. and does not exceed to any great extent the total thickness of the mottled and parti-colored beds that are exposed on the coast. Rich oil shales have been found at several places along the coast, notably 6 miles south of the village of Barreira, where a number of pits were sunk. Analyses by Boverton Redwood of the Camaragibe shale taken from these pits and of shale from Riacho Doce are as follows:

Camaragibe Shale.			Riacho Doce Shale.		
Volatile.	Non-volatile Combustible.	Ash.	Volatile.	Non-volatile Combustible.	Ash.
%	%	%	%	%	%
30·5	9·45	60·0	34·9	1·1	64·0
24·8	4·30	70·9	a 46·3	19·5	34·2
27·1	12·20	60·7	26·9	8·1	65·0
25·5	2·20	72·3	32·8	14·6	52·6
7·8	2·90	89·3	25·4	10·5	64·1

(a) A further analysis gave 4·7% S, and on distillation 44·93 gal. crude oil and 19·58 gal. ammoniacal water were produced.

The oil shales near the city of Bahia and on Itaparica Island have not been examined or worked. Beds of turfa, which appear to be of mud impregnated with bitumen possibly of great value for manufacturing gas or kerosene, have been reported on the island of Tinhare, 40 km. south of Bahia, and on the Rio Itahipe. The turfa beds on the Rio Marahu, 115 km. south of Bahia, were exploited a few years ago by a company and extravagant preparations were made to manufacture soap, paraffine and various oils. A town was built and large quantities of supplies and machinery were imported from England. Unfortunately the scale of operations was so large that the undertaking collapsed within a short time. The failure of the company, which was due to extravagance and mismanagement, cannot be regarded as a sufficient reason for condemning the oil shales of Brazil as unworkable. It is worthy of note, in this respect, that the Brazilian Government affords all reasonable protection in the way of high import duties and if these shales can be utilized, import duties will be freely laid on all the products that can be made from them. No oil shales are now known in Pernambuco, Parahyba, Rio Grande do Norte, Sergipe or Espirito Santo; but they may be looked for in these States within the Tertiary area.

Chile.—A syndicate has been formed in Santiago, Chile, with a capital of £80,000 for the purpose of working the recently discovered petroleum wells in Punta Arenas.

Peru.—Several foreign companies are actively exploiting the petroleum fields and in instances with good results. The production although increasing rapidly has not attained as yet very great importance. A refinery of 500 bbl. capacity has been established at Talara.

EUROPE, ASIA, AFRICA.—*Algeria.*—Various investigations have been made into

the petroleum deposits of Algiers, among the latest visits being that of the French expert Mr. Henri Neuburger, whose conclusions are as follows:

The geological nature and stratigraphy of the oil lands harmonize, in some respects, with the traditional nature of the petroliferous territories of the old Continent; these lands are of considerable extent, and everywhere exhibit reliable indications of the presence of oil.

The product obtained from wells sunk at Messila, and worked by the Société Lyonnaise, has the following characteristics: The sample was collected at 98 m. depth in the No. 13 pit (Cartenian formation): Natural condition: liquid color: black; density: 0·830 at 15° C.; solidification point: 12° (?); vapor tension: rather slight—evaporation 21% in four weeks, at an average temperature of 15° C. Boiling point 98° C.; percentage composition: C, 82·50%; H, 12·0%; O, 5·50%; N, (not estimated); industrial factors: light oils and loss, 5·50%; burning oils, 50·0%; heavy (lubricating oils), 12·50%; and residuum, 24·0%.

Austria.—The chief point which has been substantiated during 1900 in Galicia, is the superiority of the central field over the previously worked eastern and western oil fields. Until within the past few years the wells sunk in Galicia did not exceed about 300 m. in depth, from which level a fairly large yield was obtained. But trial borings in the Central oil field revealed the presence of a second oil horizon at a depth of 400 m. and yet another about 500 m., the last named being rich enough to produce 4,000 bbl. per day.

A large number of borings have been undertaken along a nearly straight line, and almost parallel to the Carpathian Mountains, with which it makes an angle of 9°. This line (the line of strike) slopes from N.W. to S.E., forming an angle of about 70° with the meridian and almost coinciding with the Neu-Sandec-Zagorz-Chyrow-Stry-Kolomea railway line. The petroliferous territories of Galicia begin toward the west, near the town of Neu-Sandec, from which place to Sloboda-Rungurska extends an almost unbroken line of oil lands of more or less importance. The conformation of the land in these districts differs essentially from that observed in America, the strata being for the most part disturbed, overturned and faulted; in short, a difficult country. The subsoil, however, is not of the same conformation in all cases, and very good drilling lands are often met with—*i.e.*, lands fairly free from such loose beds, or, if present, they possess a higher degree of stability by reason of their horizontal position, as is frequently the case at Iwonicz and Polana. The line of direction of the petroleum deposits in the Carpathians falls almost exclusively within the Eocene formation. The soft Eocene sandstones are the richest in petroleum, a cubic meter of this arenaceous rock containing over a hectoliter of oil. The shales and shaly clays, rich in fossils, are also sometimes petroliferous, but their yield is generally low, while the corniferous limestone which generally marks the southern boundary of the oil regions is fairly rich in oil. The output has been increased one-half within the last three years.

At Ropienka, which is connected by two pipe-lines with the railway at Olszanitza, there are a large number of wells, both producing and in the course of drilling. Central pumping rigs with rod connection, similar to the American system, are at work. The oil in this district is struck at a depth of about 500 m.,

and is approached through a very hard, coarse sandstone. No difficulty is experienced with cavings and in getting the tubes down, and pipes of small diameter may be used, as in the American oil fields, there being no sand to contend with on striking oil. The wells on producing are coupled up and pumped automatically. In this locality there are over 100 wells, averaging from 8 to 15 bbl. per day. The wells in the Galician oil fields would never pay, if it were necessary to "bail" the oil, as in Roumania and in Russia, where on account of the huge quantities of sand, a pump cannot be used. In Galicia oil is frequently struck with a 4-in. column of pipe, and no inconvenience is experienced in extracting the oil, while in Roumania nothing smaller than a 10-in. column can be employed in approaching the oil-sand to ensure a paying production.

At Muchowate three oil horizons are being worked. The red clay shales are reached at the section of the field bordering on Pasieczki, at a depth of from 650 to 810 ft., and farther away they lie at a depth of from 975 to 1,300 ft. Almost all the wells are deepened to the third horizon, the first being passed without difficulty and the water easily shut off. The Zhar field is now worked by two rigs; two wells have been deepened; 47 boreholes are being worked, of which the deepest is 1,920 ft.; an electric station has also been established.

The Austrian tax in Galicia is at the rate of 24·0% of the net profits of the individual oil company working the land.

Of the products obtained from Galician crude oil, benzine is present to the extent of about 10%. Hitherto the crude benzine has been divided into two products. The lighter portion, received from the second distillation, having a sp. gr. of about 0·7000, was previously exported, chiefly to Germany, under the name of industrial benzine; the other portion, with a sp. gr. of about 0·7400, was mixed at the refinery with so-called solar oil and sold under the name of "low-flash" kerosene. Recently, however, large refineries have introduced improved apparatus, the main features of which resemble those in apparatus employed at spirit distilleries. The distillation is carried out exclusively by steam, which removes the possible danger from fire. The chief descriptions of benzine received by distillation, and which find greatest demand are: Hydrir, the lightest benzine, with a sp. gr. of 0·630 to 0·650 (air saturated with vapors of hydrir serves as a good illuminant in specially constructed lamps); gasoline, with a sp. gr. of 0·650 to 0·670, besides being used for illuminating purposes, is used also as a solvent of caoutchouc. Motor benzine, having a sp. gr. of 0·670 to 0·700 is used in benzine motors; ordinary benzine, having a sp. gr. of 0·690 to 0·710, and extracting benzine, with a sp. gr. of 0·715, which is used in the preparation of bone meal. Hydrir is sold at 28@30 gulden per 100 kg.; gasoline at from 25@28 gulden. The price of crude benzine does not exceed 18 gulden.

Burma.—The petroleum industry of Burma has made great strides in recent years. Foremost among the oil fields stand those of Yenangyoung, on the river Irrawady, probably the oldest worked in the world; then follow the deposits on the Ramree and Boronga islands, on the Burmese coast (Aracan); and the fields of Assam, which are dealt with separately. These constitute the chief series on the eastern side of India, while on the western side we have the oil fields of Rawul Pindi, near Peshawur, and lower down the frontier the deposits of Khatan,

near Quetta. In the peninsula itself there are no known deposits, and geologists are disposed to disbelieve in the existence of any at all.

For thousands of years the oil deposits of Yenangyoung have been worked by the natives, and the product sent to every part of the East. The wells are situated on a plateau, surrounded by ravines, at a distance of about 3·5 miles from Yenangyoung; the surrounding country is barren in the extreme, and dotted with remains of extinct volcanoes.

The Burmese oils vary in specific gravity from 0·818 to 0·835, and yield from 7 to 66% burning oil, while the first of these yields 89·3% of lubricating oil, and the latter 27·3%. This last is a very valuable product, and the demand for it for machinery and other purposes is larger than generally imagined.

China.—Petroleum occurs with gas in the Province of Sze-Chuen, the principal district occupying an area of 120 sq. miles. The wells yield brine, petroleum and gas. Boring is accomplished in a very crude and primitive manner, and an enormous expenditure of time and money is required to accomplish even small results, yet a well has been sunk to a depth of 3,608 ft. There are several varieties of oil; that having a light color is used in its natural state for burning.

Dutch East Indies.—The whole petroleum region of Java and Sumatra appears to be very variable. The conditions change in a somewhat sudden fashion, and make working of oil-bearing lands a very uncertain and problematic task. The Royal Dutch Petroleum Co. has chiefly suffered from this variable state of affairs, and the production during the last few years has declined greatly. In 1898 the output reached the total of 5,500,000 cases, falling in 1899 to 1,305,400 cases, while for the 11 months of the year 1900 the output only registered 1,164,900 cases. Other companies seem to have been more successful; thus, the Sumatra-Palembang Co. produced for the 11 months of the year 1900 an output of 747,000 cases, against 693,000 for the whole of 1899. The Dordtsche Petroleum Mij. produced for the first half of 1900 more than 800,000 cases, while the Moera Enim Petroleum Co.'s output amounted, for the same period, to about 12,000 tons. Of new companies, which have been brought out during 1900 for working the petroliferous lands of these islands, are the Tegal Exploration Co., with a capital of 500,000 fl., and the Petroleum Co. "Soenzei Paga," with a capital of 800,000 fl.

The total imports into Java from the United States for the period ending November 23, 1900, amounted to 1,085,997 cases, which will probably bring the total for the year up to about the same figure as that for 1899 (1,161,949 cases).

The retail prices quoted at Batavia during the year experienced a rise toward the middle of this period, followed by a falling off toward the end of the year. For the three brands of refined oil, prices early in the year were 4·625 fl. for Devoe, 4·575 fl. for Anchor, and 4·50 fl. for Langkat, and in November, 4·30, 4·15, and 4·00 fl., respectively.

An interesting oil has been struck in the locality of Geise, Java, which is employed in the manufacture of blacks. The oil has a sp. gr. of 0·970, and is a thick syrup-like liquid of a brownish color, and having the consistency of an emulsion. It is soluble in all ordinary solvents, with the exception only of pure alcohol, is free from acid and has a strong turpentine smell. Its most characteristic property is that on being exposed to the air it quickly dries when in thin

layers. When distilled by steam a 10% distillate is obtained boiling at between 180 and 265°C., and absorbing bromine, though it is not acted upon by nitric acid. The elementary composition of the distillate is: C—86, 2%, and H—13, 5%, while that of the residuals is C—81, 2%, H—11, 3%. This latter is a thick elastic mass, of strong turpentine odor. By heating this residue, or the crude oil, for a certain time at 120°C. a hard asphaltic substance is formed. On account of the Geise petroleum possessing the above properties, it is specially suitable for the manufacture of blacks and colors. For this the oil is heated at 70°C., whereby the water and dirt contained therein are separated from the oil, and the latter is mixed with the color.

Boring is still being carried on in Java and in the isle of Madura. It is reported that one company in the latter place has found oil in paying quantities and that the raw product will be shipped to their refinery near Sourabaya as soon as the new tank lighters are ready. The agents of the Shell Transport & Trading Co., Ltd., have placed on the market a liquid fuel which is the residue from the refining of the crude petroleum obtained from the oil fields in Koeti, on the eastern coast of Borneo. From tests made on the Royal Packet and other lines, it is claimed that 1 ton of this liquid is equivalent in steam producing power to 2 tons of the best Japanese coal.

A large tank has been constructed near Tanjong Priok (the harbor of Batavia) of 4,000 tons capacity. As the Koeti supply is said to be practically inexhaustible and is but a short distance from this place it will be possible to maintain a supply of fuel sufficient to meet the requirements of all steamers trading in these seas that adopt its use.

The use of Borneo crude oil for fuel is being developed in the East. Under recent contracts it is delivered at Hong Kong or Singapore at $7·20 a ton; at Shanghai for $7·68; at Colombo and Kobe at $8·40; while it can be supplied at Suez for $12.

In Borneo the petroleum field situated in the southeastern part of the island, was not exploited until 1898, but so expeditiously was the work carried on that, by the end of 1899, 34 wells had been sunk, 25 of which were producers. The production in 1899 was 250,000 gal. since which time the work has been going on rapidly.

I described the character of the Borneo oil before the Petroleum Congress in Paris, 1900. A sample of 0·972 sp. gr. distilled without a carbonaceous residue, a fact that corroborated my opinion that it was a filtrated oil and not a primary or original one, as the latter must contain some solid carbon. A sample taken at greater depth than the first was 0·894 sp. gr., very similar to the Baku oil. On analysis the amount of light oils was very small and from its character it is indubitably a filtered oil—a second stratum oil. At a depth of 1,200 ft. a still lighter oil was obtained. It is my opinion that Borneo oil is formed at a great distance north of the island and, in its passage it is freed from light oils and heavy goudron.

Egypt.—The concession granted to Sir Elwin Palmer and Mr. Thomas Skelton Harrison extends from about the 25th parallel of latitude on the south (in the

vicinity of Esneh) to Suez, and from the river Nile to the Turkish boundary. Two wells have been sunk to depths 2,380 and 2,000 ft., respectively. In the deeper well three veins of good gas were struck and the last 300 ft. was through black, petroleum-bearing sand. A syndicate has been formed to operate this field.

India.—From prospecting which has been done in Assam by the Assam Oil Co., it is unmistakably shown that Assam contains rich deposits of oil. The wells which have been sunk are all good producers, and in several cases where the bore has been carried to a depth of 1,500 ft. spouters have been struck, yielding a very large quantity of oil. The Assam oil possesses the requisite properties for producing a very fine wax, which has a melting point of from 140 to 150°C., while its illuminating power is also high. The transport facilities are said to be excellent, not so much at present by rail as by water, by which it is possible to touch the Bengal and other outlying districts. A considerable quantity of wax is sent to the United Kingdom for use in candle making. The refinery at Margherita has been unable to meet the considerable local demand for kerosene, and another refinery is probably under construction.

Italy.—Indications of petroleum have been found in the districts of Emiliano, through the Province of Piacenza as far as Jerlo, for a distance of about 200 km., and they reappear to the south near Abruzzi, all along the Apennines, with regular branchings that extend more particularly into the Modena and Bologna Apennines toward Tuscany. The Velleja spring is now worked by a French company, which extracts about 3,000 tons of oil annually from wells drilled on the Canadian system, the depth varying from 60 to 300 m., and averaging a little more than 100 m. The petroleum of Velleja is of the lightest type, while that found at Tereo in the Abruzzi is much heavier and approximates to the bitumen type, to which it is closely allied. Of all the indications occurring in Italy the most pronounced are those met with in the Province of Bologna, which take the form of gas springs exudations and springs of petroleum, deposits of fossil wax or ozokerite. The petroleum of the Bolognese zone is of medium density, similar to that of American oil, and fairly clear, with a slight reddish tinge and a greenish iridescence due to the presence of paraffine.

Japan.—The Japanese oil fields may be classified mainly with the provinces in which they are found, namely: Hokkaido, Nemuro, Hitaka, Ishikari, Eburi and Toshima. The Hokkaido oil fields are scattered over the entire province, and in some places crude oil of a very fine quality for burning purposes is found. In the Ugo field petroleum is found in different places, especially in Nigorikawa, Izumi and Oguni districts, all of which yield a dark, heavy oil, but the total annual production is not more than several hundred barrels. The Echigo field, with the two following, forms the main oil field of Japan at the present time. The Province of Echigo is situated about 200 miles north of the capital, Tokyo. The province is a very narrow extension of land of about 250 miles long by 75 miles in width, running along the entire length of the Japan Sea on the northwest. Oil is found mostly in the central part, though the natural exposures are scattered throughout the whole of the province. The Shinano field is a continuation of the Echigo field, and although there are many natural ex-

posures of oil, very few wells are worked which give 20 to 30 bbl. per well per day. The Totomi field is located on the Pacific Coast, and there is no connecting oil vein between it and the Shinano oil field at all. From the point of view of production and quality it is, at present, the second important oil field. The oil territory extends from southwest to a distance of more than 30 miles, with an average width of 10 miles. It produces several hundred barrels of crude oil per day, which is the most suitable for burning. More than 200 wells are in existence, most of them sunk by the shafting and artesian methods.

Petroleum deposits exist in Formosa, but active work has not yet been done in the island. It is a very promising territory, as it has close geographical as well as geological relations with the Java and Sumatra oil field.

The Echigo oil fields were discovered in the latter part of 1899, and are the richest in Japan. It was not an infrequent occurrence that a well was struck yielding more than 400 bbl. of oil per day, sunk to a depth of from 600 to 700 ft., a depth bored in less than two weeks by the American method of drilling. These new oil fields have now become the center of the oil business of Japan. The Japan Oil Co. put down wells at Hoden, Zawo, Tokyo, etc., as fast as they could, and more than 100 producing and 50 refining companies have been established in the vicinity of Kamada and Nagamine. About 10 pipe-lines were started, 3 in. and 4 in. in size, at varying distance between the refineries and the oil wells. The total daily production of petroleum in Japan, which was only 2,300 bbl, a year ago, is now more than 4,000 bbl., and the annual production will now amount to about 1,400,000 bbl., while in 1899 it was only 800,000 bbl. Japan consumes annually about 60,000,000 gal. of refined oils, while the domestic refineries produce about 20,000,000 gal. Soon after the discovery of the new oil fields more than 70 producing and 30 refining companies were started in Kashiwazaki, the city nearest to the field. The general conditions of the Japanese oil industry may be summarized as follows: The oil fields extend from Torinosa in the south to Hokkaido in the north, and the oil is found in almost every province. Echigo is the only province where the field has been worked and this province yields more than 90% of the total oil production. The daily production of the entire oil territory is about 4,000 bbl. There are many kinds of petroleum in Japan, as in America, but through the chemical researches which have recently been completed it is proved that almost all the petroleum in Japan belongs to the methylene series of hydrocarbon compounds; that is, C_nH_{2n}, like the Russian and Californian petroleums rather than the Pennsylvanian oil, which belongs to the paraffine series (C_nH_{2n+2}). The

	No. of Refineries.	Barrels.
Amaze	18	870
Kashiwazaki	30	1,384
Nagaoka	38	1,510
Niitsu	4	250
Other places	5	200
Totals	95	4,214

specific gravity of Japanese oil is variable, ranging between 14 to 47°B., and yields about 50% of burning oil. According to market quotations on June 15, 1900,

the price of crude oil was as follows: Amaze, $3·25; Urase, $1·50; Nagamine, $0·95; Kamada, $0·85; and Niitsu, $0·38. There are 95 small refineries, of a total capacity of 4,214 bbl., which is greater than the daily production of petroleum.

The importation of refined oil from the United States, Russia and Sumatra, has been increasing yearly and still remains third on the list of articles imported into Japan. The total demand of all kinds of refined petroleum in Japan may be calculated at about $10,000,000 a year, while the domestic supplies are about $3,500,000; that is, a little over one-third of the total demand of Japan. About 12 years ago the entire oil fields produced only 30,000 to 40,000 bbl. annually. In 1890 it was increased to 60,000 bbl. In 1894 it was 140,000 bbl., then an abrupt, a sudden increase occurred during the year 1899, and the output amounted to about 900,000 bbl. Since the discovery of the Kamada and Nagamine oil fields at the end of last year, the annual production has increased to about 1,800,000 bbl. It will not be long before the annual production of petroleum in Japan reaches 5,000,000 bbl. a year, and takes its place as the third oil-producing country in the world.

The nature of petroleums found in Japan varies according to their localities. Some are black and a little heavier than water, like asphalt, while others are light in both gravity and color. The lightest crude gives more than 55% for benzine, while the heaviest kinds contain 80% as residuum. The sp. gr. of the petroleum ranges from 0·8245 of Amaze to 0·9435 of Kuguchi origin. While the remainder are 0·8622, 0·8771, 0·8952, 0·8911, 0·9210 for Hirei, Katsubo, Kitatany, Miyagawa and Kusodsu, respectively.

A long and exhaustive investigation has been made into the various qualities of Japanese petroleum by Prof. Shin-Ichi Takano, the results of which were laid before the International Petroleum Congress at Paris, 1900. The conclusions arrived at were as follows: The petroleums belong to the hydrocarbon of the methylene series (C_nH_{2n}). Two out of seven petroleums contained paraffine wax of solid hydrocarbons. The percentages of sulphur and nitro compounds are generally high, varying from 23 to 83% of the former, and from 35 to 1·34% of the latter. The coefficient of expansion of the crudes is variable, being from 615 to 825. The calorific powers of the crudes are higher than any of the American or Russian petroleums. No oxygen compounds were proved to exist in the Japanese petroleums in this examination. The results of the examination proved that the chemical nature of the Japanese crudes resemble more closely the Russian and Californian petroleums, than the Pennsylvania oil.

Persia.—Petroleum is found in various parts of Persia. At Daliki, about 50 miles from Bushire, the natives collect nearly 20 gal. of oil per diem in a shallow reservoir constructed near a hot sulphur spring at the foot of a limestone hill. The oil is of a yellow color and clear, with an agreeable aromatic odor. The sp. gr. is 0·81 and it burns with a clear smokeless flame in lamps. The strata, composed of yellow marl, limestone and gypsum, are greatly disturbed, the marl constituting the upper layers on the flanks of the mountain chain, but giving way to dense yellow limestone, alternating with beds of gypsum, in the hills themselves. Another deposit of oil was discovered in the Minab (Bender Abbas) district, near

the village of Chanawallah. The hills here consist of limestone without the gypsum and marl found at Daliki. Here a water spring has been observed, smelling of hydrogen sulphide, and issued from a fault in the limestone, which is dense in structure, gray and traversed by numerous veins of calcite.

Petroleum was also found on the island of Kischim, in the Persian Gulf, in a small valley 2·5 miles from the coast, and 9 miles from the Namakdan salt beds. The oil is dark in color and burns with a very smoky flame; a trial boring, however, led to no result, and further search was regarded as hopeless.

Roumania.—According to statistics compiled for the 40 hectares worked from 1857 to 1896, the total production was 118,000 ten-ton wagon-loads of petroleum, which gives an average yield of 2·950 wagon-loads per hectare. On this basis the 20,000 hectares of the Roumanian petroleum zone would be valued at nearly $12,000,000,000. In 1899 a single well (No. 12) of the "Steaua Romana" Co., at Campina (Prahova district) produced 70 loads of oil per diem for 39 days, equaling a pecuniary return of 682,500 f. ($136,500). The flow diminished a little afterward, but has not ceased.

At the end of 1898 there were 1,119 dug wells and 123 boreholes, 70% of which were in Prahova; about one-half of these were unproductive.

The production of petroleum in 1899 was 30,000 tons against 15,000 in 1897.

At the present time more than 320,000 tons per annum are produced, and over 4,500,000 gal. are shipped to England. This quantity is obtained from 900 hand-dug wells and 82 boreholes, and is distilled in 75 refineries, eight of which are fitted up in modern style. A petroleum, hand-dug well is an excavation measuring from 48 to 60 in. in diameter or side, lined with planks or interlaced branches of trees. The sinker engaged in digging the well is supplied with fresh air by means of a metal pipe fed by a fan at the surface, in order to renew the atmosphere in the well by driving out the hydrocarbon emanations. Infiltrations of water or oil, when of small amount, are removed by baling into the tubs which are used for lifting the excavated earth; but when the inrush of water is too abundant the well becomes flooded and is abandoned. If the oil horizon is rich, and the pit is filled with oil to a certain depth, the extraction is done with buckets, raised by a horse winch, and the work is continued for months, perhaps, years, until the supply of oil gives out. The well is then deepened, until a second bed of oil is reached, subsequently a third, and so on as deep as possible, unless prevented by the well caving in or by some other accident. The cost of sinking a well of this kind to a depth of 120 m. is about 6,300 f. ($1,200). The yield obtained is very variable; when it reaches 10 tons a day the well is considered very productive. An output of 1,000 bbl. per diem, on the other hand, is sufficient to cover expenses.

At the distilleries and railway stations the oil is stored in sheet-iron tanks. Conveyance by rail is effected in tank cars, generally the property of the larger well owners or refiners. The seaports of Constantza, Giourgiou, and Cernavoda are provided with special installations belonging to the shippers, and consist of large metal reservoirs, pipe-lines, pumps, and pontoons for facilitating the loading of the oil on shipboard.

The tectonic and stratiphical conditions of the petroliferous formations are

now for the most part elucidated. It has been found possible to trace certain petroliferous anticlinals for more than 100 km., and the importance of several zones has been determined to a depth of 450 m., by borings over an area extending from the shores of the Jalomitza (Dambovitza) as far as Jaslau (Moldavia). There is still wanting a series of 10 to 15 borings, at a depth ranging from 700 to 1,000 m., in order to establish definitely the extent of the Roumanian petroliferous deposits and the true riches of the subterranean treasure house. The area may, however, be fixed at a minimum of 20,000 hectares (nearly 50,000 acres), capable of producing 1,500 wagon-loads per hectare (2·5 acres) from the various horizons encountered down to a depth of 400 to 500 m.

The chemical composition of Roumanian petroleum varies between 86·17% C, with 13·79% H (Campeni oil), and 87·57% C, with 11·37% H (Ocnitsa oil). Oxygen is never found in larger proportions than 1%, and sulphur is rarely detected even as a trace. As a rule, the sp. gr. of the oils, as they come from the wells, is from 0·7900 to 0·8700. The lighter colored crude oils have the lowest specific gravity, and the darkest and most opaque are the densest, which results from the fact that the light colored oils, having simply been clarified and freed from tarry constituents by natural filtration through porous clay strata, are endowed with the property of decolorizing petroleum by retaining the amorphous matter therein. Nearly all the oils flash below 0°C. on the approach of a light. Those flashing at a higher temperature (*e.g.*, Gura-Ocnita, Tega and Matita oil) have probably not been taken direct from the wells, but from storage reservoirs, where the oil has lost its very light gaseous hydrocarbons by evaporation. The lowest viscosity was exhibited by Campeni-Parjol oil (1·04), the most viscous being that of Sarata-Tohani, which is 4·80. In general, the viscosity ranges between 2·00 and 2·80, the higher viscosity of other oils, such as those of Sarata-Tohani, being probably due to long exposure to the air, with consequently oxidation and the loss of light hydrocarbons by evaporation. Nearly all the oils boil between 25 and 62°C.

Russia.—The output from the Russian fields for the year 1900 shows a very conspicuous advance on that of the year 1899.

In 1899 the total quantity of oil received from the wells in the Baku district, amounted to 8,470,925 metric tons; for 1900 the total quantity obtained amounts to 9,782,721 tons, or an increase in round numbers of 1,300,000 tons. Of the total yield 1,161,633 tons were from spouters and 8,621,088 tons from pumping wells.

The Russian petroleum industry has been a great attraction for British capital during the past year, a larger number of important companies having been launched in London perhaps than in any previous year. These included the Bebe-Aibat Petroleum Co., with a capital of £460,000; the Anglo-Baku Petroleum Co., with a capital of £200,000; the Spies Petroleum Co., capital, £700,000; the Anapa Liquid Fuel and Petroleum Co., capital, £1,000,000; Russian United Pet. Co., capital, £200,000; Braguny Pet. Co., £100,000; while the Consolidated Petroleum Co., in which the Russian distributing interests in this country are amalgamated, has been launched with a capital of £500,000, representing in all a total nominal capital of £3,860,000.

As I have frequently pointed out, the mistake so often made in launching a company of this description, is the inadequate sum set aside as working capital. The result of this policy has often been disastrous and has cast obloquy on the Russian industry, nipped further enterprise in the bud, and hampered the development of the natural resources of the country.

The petroleum bearing land of Russia is wholly in the hands of the Government, and the leasing of plots is generally effected by auction. The only leasing of petroliferous lands in Russia which occurred during the year 1900 took place at the auction held on November 29; the plots are located in the districts of Saboontchi, Bebe-Aibat, Balachany and Binigadi, and cover, in the aggregate, an area of 309·8 acres.

The Bebe-Aibat district is chiefly responsible for the increase referred to above, and its progressive movement will be seen from the following table of percentage of total production:

Field.	Percentage of Total Production.											
	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Balakhany.....	39·5	32·0	31·3	24·4	21·9	23·4	20·4	23·4	23·8	22·4	21·8	20·6
Bebe-Aibat.....	8·4	7·9	8·7	11·6	14·6	11·4	12·5	18·2	14·9	19·9	15·2	18·2
Romany.....		0·8	4·8	14·3	22·5	20·7	29·5	20·2	22·8	20·7	17·6	18·9
Saboontchi.....	51·1	59·3	55·2	49·7	41·0	44·5	37·6	38·2	38·5	37·0	43·8	41·4

Field.	Depth of Wells.						
	1894.	1895.	1896.	1897.	1898.	1899.	1900.
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Balakhany.....	640	624	701	696	720‡	795	749
Bebe-Aibat.....	814	1,261	1,215	1,472	1,601	1,309	1,211
Romany	1,108	1,080	1,214	1,295	1,439	1,339	1,428
Saboontchi.....	1,020	1,030	1,030	902	966	994	847

Russian oil producers have hitherto largely depended on spouters for their profit, but the day of the spouter is passing away, and a prolific spouting well in Russia is now the exception. Very marked fluctuations are noticeable in the quantities of oil produced by spouters in the various districts. In 1891, the quantity obtained by spouters amounted to 30%; in 1898, to 23%; in 1899, to 18%, and in 1900, 13·5%. The difficulty of dealing with so vast a quantity of oil thrown out by a spouting well was no unmixed blessing, as the unavoidable waste was enormous, no means being at hand to treat the sudden outburst. A good pumping well is therefore regarded by leading men in the industry as much more profitable, and in the long run more productive than a spouter. In fact, the presence of the spouter would seem to be one of the essential characteristics of early development of an oil region, which must gradually disappear as the field settles down to what may be termed its adolescence.

An interesting table on the life of an oil well in Russia, which was given in a report published by the Baku Technical Association,* throws additional light on the Russian oil fields:

* *Petroleum Review*, Jan. 6, 1900.

Number of Wells Completed.	When Exploited or Completed.	Number of Wells Under Exploitation in 1898.	Production in 1898.	Average Production per Well Exploited.	Average Production per Well Completed.	Number of Wells Completed.	When Exploited or Completed.	Number of Wells Under Exploitation in 1898.	Production in 1898.	Average Production per Well Exploited.	Average Production per Well Completed.
Of 227 wells.	1888	125	13,458,272	107,666	59,287	Of 87 wells.	1894	67	28,310,953	422,551	325,413
" 47 "	1889	21	4,213,956	200,664	89,658	" 80 "	1895	60	35,891,234	598,187	448,640
" 81 "	1890	40	9,886,321	247,158	122,053	" 135 "	1896	113	46,460,459	411,154	345,484
" 142 "	1891	90	22,895,225	254,391	161,233	" 212 "	1897	190	94,194,276	495,759	444,312
" 80 "	1892	52	15,522,399	298,507	194,029	" 259 "	1898	259	105,550,725	407,531	407,531
" 64 "	1893	38	12,805,015	336,974	200,078						

A report* published by the Naphtha Association of Baku, gives the detailed cost of the various requirements for boring a well in Russia. The total cost of boring is as follows:

	Feet.	Rubles per 7 feet.	Total Cost in Rubles.		Feet.	Rubles per 7 feet.	Total Cost in Rubles.
For first	700	700 × 82·5	8,250	For following	70	70 × 162·5	1,625
For following	70	70 × 92·5	925	" "	70	70 × 182·5	1,825
" "	70	70 × 102·5	1,025	" "	70	70 × 202·5	2,025
" "	70	70 × 112·5	1,125	" "	70	70 × 222·5	2,225
" "	70	70 × 122·5	1,225	" "	28	28 × 242·5	970
" "	70	70 × 132·5	1,325				
" "	70	70 × 142·5	1,425	Totals....	1,428		23,970

The reproach that has so long rested on the Russian producers, is being but slowly removed. The bulk of the oil is used for fuel purposes, and refined products are not produced in such quantities as to occupy that place in foreign countries which its superior production of crude oil entitles it to.

The only chemical materials employed in different petroleum industries are sulphuric acid and caustic soda, of which such large quantities are used in Baku that the acid pitch and alkaline waters obtained would afford materials enough for an independent industry for at least one or two large factories, which could work up these wastes into valuable products. Only a small part of the acid waste, however, is regenerated, and by a method not sufficiently economical.

The position of the small refiners in Russia is a somewhat unsatisfactory one. Economical improvements in their plant and processes would be a boon which would relieve them of such utter dependence on the large firms. Unfortunately, however, financial considerations of another description prevent any large expenditure in this direction.

In some markets Russia has made great strides during 1900, in others America has advanced, particularly those in the Far East. At present Russian interests are devoting the whole of their attention to the expansion of the use of oil in the United Kingdom. A very wide field is here provided for Russian oil, and with the consolidating of the distributing agencies in England, no doubt, the advance already begun, will proceed at a greater pace.

In regard to other countries Russia has not fared so well. Her shipments to the Far East—the most important markets after the United Kingdom—have shown a most disastrous falling off. For the first six months of 1900 the picture represented by the case oil statistics is a very dreary one, and this is not only

* *Petroleum Review*, Jan. 20, 1900.

attributable to the advance America has made, but also to the growing ability of the fields of the East Indies to cope with the requirements of the Orient.

The stocks of oil at the refineries have shown a gradual decline during 1900, closing the year, however, with a considerably higher figure. At the end of 1899 they amounted to about 1,577,684 tons, and at the end of 1900, 1,972,700 tons.

The prices during the year 1900 are shown in the annexed table:

Month.	Refined.		Residuals.	Crude.
	Inland. Copecs per Pood.	Export. Copecs per Pood.	Copecs per Pood.	Copecs per Pood.
January.....	30·66	55·00	15·00	16·58
February.....	30·75	48·38	15·13	15·91
March.....	29·63	47·75	15·75	16·00
April.....	30·19	50·38	17·00	17·75
May.....	26·25	34·75	17·56	17·75
June.....	23·81	33·19	18·50	18·13
July.....	23·06	27·94	18·75	17·56
August.....	21·31	28·63	18·38	17·31
September.....	19·81	24·88	17·81	16·50
October.....	17·00	17·50	15·80	13·88
November.....	16·43	21·63	13·88	12·69
December.....	15·75	22·50	13·66	12·38

NOTE.—1 copec=$0·0051; 1 pood=36·1132 lb.

The working of English companies in Russia has been, on the whole, very profitable during 1900. The chief among the English companies working petroleum lands in Russia, is the Russian Petroleum and Liquid Fuel Co., which stands sixth on the list of large petroleum producers in Russia. For the fiscal year of this company, ending September 13, 1900, the total output amounted to 34,076,353 poods, over 25,000,000 poods of which was produced from wells reopened and bored by the company itself. This was instrumental in bringing in a net profit amounting to £378,170, and a dividend of 70% per annum for the six months was declared or with the interim dividend of 30% for the first six months, an aggregate dividend of 50% for the year. For the last financial year of the Schibaieff Petroleum Co., the output amounted to only 8,000,000 poods, against 11,000,000 poods for the previous year, due to difficulties encountered in some of the wells.

The total output for the year 1900 of the three English companies working petroleum lands in Russia, amounts in round figures to the following: The Russian Petroleum and Liquid Fuel Co., 32,000,000 poods; the Baku Petroleum Co., 18,000,000 poods, and the European Petroleum Co., 11,000,000 poods.

The Grosny field has been brought into greater prominence during the past year by reason of the fact that the chief exploiters in that district have disposed of their property to a company, recently launched in London, known as the Spies Petroleum Co.

Since June, 1900, progress in the development of the Grosny properties has been made. There are now 17 wells, distributed as follows: 8 wells on plot No. 15, 7 wells on No. 16 and two wells on plot No. 32. Of these 17 wells 12 are in active operation, namely 6 on plot No. 15, 4 on plot No. 16, and 2 on plot No. 32, the remaining 5 wells being still in course of drilling. The wells are an average depth of about 660 ft., and at present only the first oil stratum has been reached; the total output of this district during 1900 is calculated by the Government as amounting to 29,000,000 poods, as against an estimated output for

1899 of 23,200,000 poods. It is well known that all the big spouters of the Grosny oil fields are struck in the second oil bed, and Spies, Stucken & Co. had the good fortune to obtain a spouter from the first oil stratum which had a daily output amounting to over 150,000 poods, lasting several days. The well is now bailed and yields on an average 7,000 poods per day.

The Binigadi field has been exploited to the extent of 1 square verst. There were 16 wells in course of pumping and a total production of not more than 1,500 poods per day. Most of the wells are between 210 and 280 ft. deep. One well which was sunk to a depth of 938 feet yielded no oil. As a rule the wells in Binigadi produce at first about 300 poods per day.

The oil is a heavy one, and can only be used for fuel purposes. Its price at the well varies from 9 to 13 copecs per pood, and is less during the winter than at other times of the year. There is under consideration at the present time the putting down of a 4-in. pipe line from Binigadi to the railway station of Balajary, which is a distance of about 2·5 miles. At the present time oil is transported by skins on camels.

Chief among the new petroleum districts of Russia, recently investigated, is that of the Emba-Caspian region, a detailed description of which appeared in *The Petroleum Review,* September 29, 1900.

The naphtha is of excellent quality, thin and liquid; its sp. gr. on the spot was found to be, at 14°R., 0·853, and its smell was not disagreeable. It was superior to most of the Baku samples, and may be compared with the Pennsylvanian oil.

The discovery of extensive petroleum deposits on the island of Saghalin, Eastern Siberia, is reported. One area near the river Nutowo, is said to contain pools of oil supplied by natural wells. The Saghalin & Amour Mining Syndicate, Ltd., with a capital of $500,000—an English syndicate—has been formed to work the field.

Turkey.—From investigations made on the property of the European Petroleum Co., on the sea of Marmora, the following conclusions were arrived at: Issues of oil are here very rare, though on the other hand the geological formation of these localities points to the possibility of finding oil in them; and if the latter were manifested, the exploitation of the same would prove very profitable from a technical point of view, on account of the known structure of the layers, as well as from a commercial point of view. The existence of oil may be regarded as very probable, taking into account the existence of issues of natural gas near Myriophyto. The oil, if found, would be in large quantities on account of the presence in thick layers of sand and sandstone, outcrops of which were observed in several places. Therefore it would be practicable to sink one well in the valley situated between Hora and Sharkioi, and the more to the south in the direction of Sharkioi, and the more to the north in the direction of the main mountain ridge the better. In case this well proves the existence of oil in this part of the country, the presence of oil may also be expected on the islands of Marmora and Aphsia, as well as in the southeastern districts of the Marmora basin, and especially in the Lake Isnik district.

Shale Oil.

The Scotch Shale Oil Industry in 1900.—The year 1899 closed with very favorable prices to the oil producers of Scotland, the latter half of the year experiencing a gradual increase, which for solid paraffine, one of the most important products, amounted to 1·5d. per lb. over that ruling during the two preceding years, and thus the prospects for 1900 may be said to have warranted the belief that the industry was on the eve of an era of prosperity.

Burning oil now occupies third place in the matter of revenue to the oil companies. The Associated Companies were, however, in a position to establish an advance of 0·5d. per gal. over the prices prevailing during the preceding season, which, in the autumn, brought the price for the winter's output up to 7·25d. and to 7·5d. per gal. according to quality.

The price for naphtha fluctuated but little, being about 10d. to 11d. per gal., the same price obtained in 1899.

At the beginning of the year prices for gas and lubricating oils ranged between £7 and £9 per ton, according to gravity. In November a drop of about 15s. took place.

The Scotch mineral oil industry relied upon solid paraffine for its mainstay during 1900. Semi-refined wax of 118·20°F. melting point, toward the close of 1899 reached the high level of 3d. per lb., compared with 1·75d. per lb. for the two preceding consuming seasons, and in the first month of 1900 a rise of 0·5d. per lb. occurred. Consumption has increased enormously, and the price is governed by that of stearine.

In regard to the status of the different companies, the Pumpherston Oil Co. headed the list with a dividend of 20%, besides paying off 3% of arrears on the preference shares. The Broxburn Co. followed with a dividend of 15% for the year, besides placing £5,000 to the credit of retort renewal account and £10,000 to reserve account. The Oakland Co. paid 7·5%, and placed £10,000 to retort renewal account. The Young's Company wiped off a debit balance of £21,157 and placed £10,000 to credit of retort renewal account, and the Linlithgow Co. cleared off a debit balance of £4,202. The Caledonian Co., which was reconstructed and made a fresh start in 1899, closed their first year with a credit balance of £459, but there was really a loss on the year, as this sum was insufficient to pay mortgage interest. The reconstructed New Hermand Co. joined the ranks of the crude oil producers in the latter half of 1899, and their first balance-sheet shows a sum to the debit of £1,763; this company, however, has within the past few months increased their nominal capital by £30,000. The Holmes Co., which was a crude oil producing concern only, abandoned its mineral workings in September, 1900, and is now being wound up.

New Zealand.—A new and complete plant is in course of erection at Orepuki for working the extensive shale deposits in that district. The plant will treat 2,000 gal. of crude oil per day with a possible extention to 4,000 gal. The experimental work on the shale has yielded pure oils for lighting and lubrication purposes which were free from the unpleasant mineral odor usually present in oils of this character. The company is providing machinery for the treatment of all the by-products.

The Origin and Occurrence of Petroleum in California.

By A. S. Cooper.

California petroleum oil is derived from organic matter contained in rocks from which it was distilled by metamorphic heat, the vapors from this distillation ascending and condensing in superincumbent strata. The condensations were then carried upward by associated waters and stored in porous and seamed rocks, incased by impervious rocks, or reached the surface of the earth and were lost. The visible results of these processes are so manifest, and all the coincidents agree so harmoniously, that they are presented rather as facts than theories. Asphaltum is the residue of petroleum after the evaporation of the volatile parts of the oil and the geological conditions of the one pertain to the other as well.

In California, unaltered rocks, consisting principally of shales and sandstones cover an area of 40,000 sq. miles, all of which contain bitumen in greater or less quantity. The prevailing rocks of the sedimentary strata are shale and sandstone, and must have been of immense thickness before being metamorphosed by the heat produced from organic movements or otherwise. At the present time exposed strata show a thickness of 10,000 ft. The alteration by metamorphic heat of this great thickness of sedimentary rocks, which must have contained organic matter in considerable quantity, is the source of the bitumens.

The strata forming the Coast Range of California are contorted and denuded to such a degree that strata of different rocks both unaltered and altered, together with their position and relation to each other, can be plainly seen, and studied.

Some of the oil sands must have been at one time 10,000 ft. below the ocean level, yet they now lie 2,000 ft. above this plane. At some places the metamorphic rocks are in contact with the bituminous sands; whereas, a few miles distant the metamorphic rocks are more than 1,500 ft. below a continuance of the same oil sand. The Coast Range extends along the entire length of the coast of California, and consists of a series of more or less parallel anticlinal ridges broken by transverse passes and separated by synclinal valleys. These ridges may be prolonged for a few miles only, or may extend for hundreds of miles, and frequently coalesce. The cores of the main anticlines are granitic or metamorphic rocks, and a part, if not all of the Coast Range granites are metamorphic.

Nearly all the marine sedimentary rocks have been denuded from the west side of the Sierra Nevadas, exposing immense masses of plutonic and metamorphic rocks. The anticlinal folds extend from a few to many miles and they sometimes coalesce. They undulate along the line of their strike and form a chain of domes. These domes have the appearance of an anticline with its axis at various angles with the general trend of the main anticline. The axes of the anticlines are usually parallel with the trend of the mountains and hills in which they occur, and, owing to the climatic conditions existing in the Coast Range south of San Francisco, *i.e.*, the small annual rainfall which must have been the same for a long time, the axes of the anticlines are also the axes of the chains of the mountains or hills. The prevailing direction of the mountain chains of California is about N. 35° W., and S. 35° E. Where the metamorphic rocks,

burnt shales, jaspers, and serpentines are exposed, they generally form the core of an anticline. This is shown in many places and it is fair to presume that they form the core of the majority of the anticlines of California, even when they are not visible.

Compared to the Sierra Nevada there is but little exposure of granitic rocks in the Coast Range, and these are generally shown on the axes of the anticlines, which as a general thing are the summits of the mountain ridges. The upper and more recent metamorphic rocks, burnt shale, serpentine and jasper, are but little eroded and large areas and masses of unaltered marine rocks repose upon altered rocks on the sides and summits of these mountains. Along the axes of the anticlines the surface of the metamorphic rock is often very irregular and the adjoining sandstones and shales are broken and contorted, a condition which decreases in the overlying unaltered rocks the further they are from contact with the metamorphic rocks, until finally the unaltered rocks assume graceful curves of large radii, showing that the unaltered rocks were not derived from or deposited upon the altered rocks, after they were metamorphosed, but that the metamorphic rocks were from the unaltered rocks.

As many as ten beds of sandstone with intervening beds of shale can be seen on the eroded sides of some of the anticlinal ridges. These sand beds are very irregular in thickness and in the distance intervening between them. Some are a few feet in thickness, while others exceed 400 ft. The shale beds are from a few feet to over 500 ft. in thickness. When several sand beds are to be seen on the side of a mountain, or when they can be traced upon the surface of the earth by their outcrop, if bituminized at all, the bitumen will generally be in the geologically lower beds, and when a sand contains bitumen, the geological underlying beds until metamorphic rocks are reached, are also liable to contain bitumen.

The large area covered by the unaltered rocks and their great thickness, consisting of numerous alternating beds of sandstone and shale, make the possibilities of petroleum in California seem almost incredible. Throughout the bituminous sand are a number of lenticular pieces of shale which have been silicified forming chert. Their surfaces, however, still retain the appearance of shale and when broken show its lamination. The silicification therefore must have occurred before the sands were bituminized and was probably effected by the infiltration of hot silicious waters. The creation of this water was probably through the agency of metamorphism which preceded the distillation of the petroleum from carbonaceous matter by the heat of metamorphism.

Mineral springs of different degrees of temperature from the warmth of the atmosphere to boiling, abound near the axis of the anticline and mineral water almost always accompanies the ascent of the bitumens in California.

The anticlines in a number of places are made conspicuous by the presence of white shales and sandstones, and at times this is true of bitumen deposits as well. Some anticlines can be traced for miles by their whitened rocks. The heat and chemical action attending the metamorphism in the depths of the earth has liberated carbonic acid, hydrogen sulphide and other gases, also hot mineral water; these gases, together with the water, in passing through the shales and

sandstones have leached and removed from them the alkalies, magnesia, lime and metallic oxides, leaving them in many instances very white.

Shales near the axis of the anticlines are frequently found with every crack and seam filled with bitumen. At times these shales are soft and can be easily scratched with the finger nail, while at others they are hard and flinty, having been converted from their original soft condition to the present hard one by

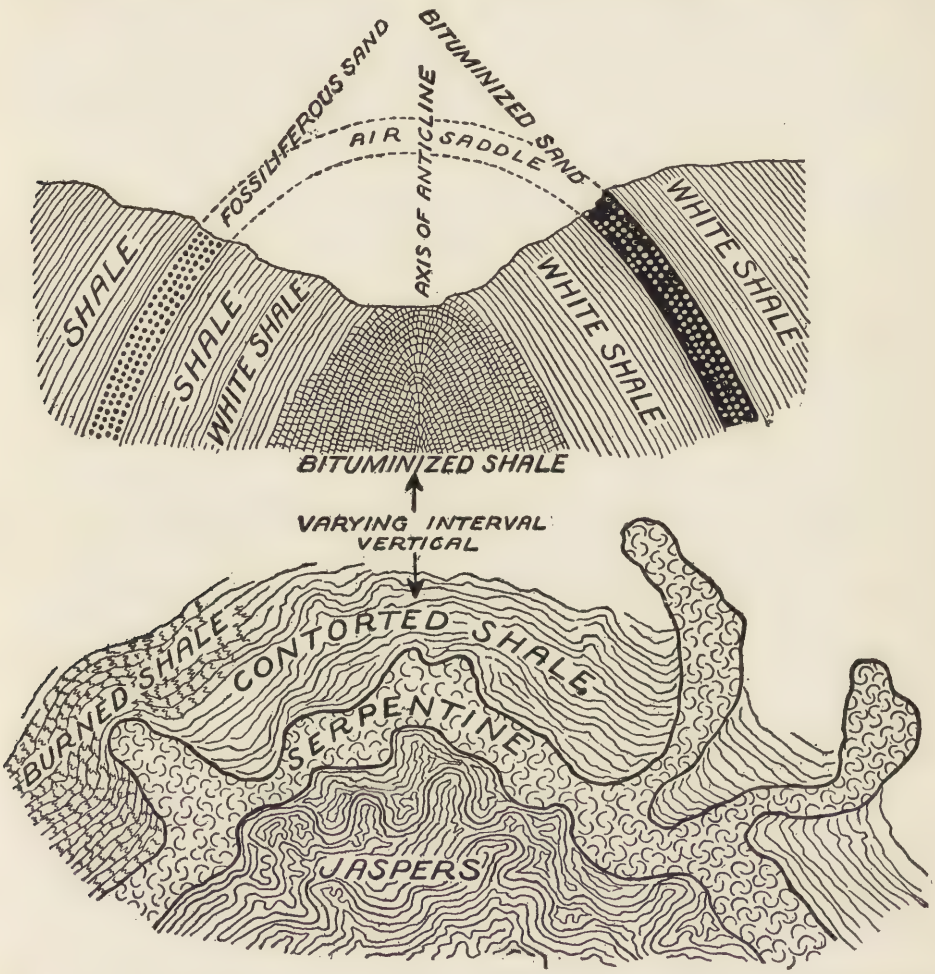


FIG. 1.—ILLUSTRATION TO SHOW THAT BITUMINIZATION OCCURRED AFTER THE FORMATION HAD BEEN PARTLY UPLIFTED.

infiltrating silicious waters in the same manner as the lenticular pieces of shale previously described. When black they show that bituminous matter accompanied the flow of the silicious waters. The black color of silicified black sands also shows the presence of bitumen while they were being filled with silica.

In one instance leaching, silicification and bituminization of the bituminized sand must have occurred after the formation was partly uplifted and after the

bending of the strata had begun, for this stratum, on the other dip of the anticline is not leached, silicified or bituminized. Frequently the sand on one side of the axis of an anticline will be bituminized and contain but few fossil shells, whereas, the same sand stratum on the other side of the axis will be highly fossiliferous and contain no bitumen, but may be silicified. This condition is well illustrated in Fig. 1.

In the oil fields of Pennsylvania and other Eastern States there are few if any surface indications from which a judgment can be made as to the existence of petroleum oil within, or the depth at which it can be formed below the surface, a condition that makes the attempt to find the oil in an undeveloped territory purely and simply "wild catting"; while in California there are many surface indications from which conclusions may be deduced—the outcrop and dip of the bituminized strata; the position of the bituminized strata in regard to other strata; the presence of carburetted hydrogen on the surface; of mineral water springs; of leached and metamorphic shales, and other evidences of the presence of petroleum.

Natural gas is found in numerous places and wells in California, but little is found in a free state. It is generally in solution with petroleum oil or water, for when the oil or water ceases to flow, the gas nearly always ceases. The gas is not confined to the anticlines for the reason that it may be carried in any direction by the water in which it is dissolved so long as the requisite pressure is retained. The greater the pressure the larger the amount of natural gas dissolved in water. When the water containing the gas flows upward toward the surface of the earth, the pressure is reduced and the gas is released which makes it appear as if free gas were present; but if an examination is made it will be found that there is no more gas present than that which the accompanying water could absorb under the pressure maintained at the bottom of the well. Of course when a reservoir of oil or water is first opened and the pressure relieved where the gas dissolved in the fluids is under high tension, there will be a violent flow of gas and probably of liquids also for a short time. A bottle of champagne acts in the same manner when the cork is withdrawn. To a certain extent this is also the cause of a gushing well. Besides being urged toward the surface by gas and hydrostatic pressure, sands and shales formed into a bituminous mud are forced upward by rock pressure in the most surprising manner. The genesis of Californian asphalt is described in detail in THE MINERAL INDUSTRY, Vol. VIII., p. 53.

Petroleum oils from the various oil fields of California differ widely in physical characteristics and chemical composition. In addition to carbon and hydrogen they contain chemically combined, sulphur, oxygen and nitrogen, singly or together, and in widely varying amounts, while in some rare instances they may be absent. Oils in the same stratum and a short distance apart may vary greatly in composition. The California product may be regarded as containing the following elements in an unknown state of combination: carbon, hydrogen, nitrogen, oxygen, sulphur, and others in minute quantities; these combinations being very numerous and extremely complex.

The boiling and melting points of the bitumen are altered very considerably

by the presence, even in traces, of sulphur, oxygen and nitrogen. The presence of a greater or lesser amount of these substances during distillation has an influence on the distillate. Generally the larger the amount of carbon, sulphur, oxygen or nitrogen an oil contains, the greater its specific gravity, and the higher its boiling and melting points.

Temperature and pressure exercise a considerable influence on the nature of the products of distillation. The method of cooling also exercises great influence in the rearrangement of the molecules and upon the nature of the product of distillation. In the California bitumens the sulphur compounds usually predominate, followed by oxygen, then nitrogen, and lastly the other elements in smaller quantities. The sulphur, oxygen, and nitrogen compounds were formed at the time when the oil was distilled from carbonaceous rocks by the heat of metamorphism, which occurred under a great variety of conditions, and accounts therefore for the great differences in character, or else they are substitution compounds formed subsequently to the distillation by the hydrocarbons coming in contact with the substances under different conditions. Petroleum, when exposed to the air, absorbs oxygen, and when heated with the peroxides it reduces them to a lower state of oxidation. It also absorbs sulphur when exposed to sulphurous vapors.

PHOSPHATE ROCK.

THE production of phosphate rock in the important fields of Florida, South Carolina and Tennessee did not reach the high mark of 1899, although there was a large output comparatively during the early months of the year. The shipments to European ports showed a marked decline owing to the prevailing high ocean freights and scarcity of suitable bottoms, and while the domestic trade increased somewhat, there were considerable accumulations of stocks at the close of the year, and the outlook for 1901 gave little encouragement.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (*a*) (IN TONS OF 2,240 LB.)

Year.	South Carolina.	Florida.	North Carolina.	Tennessee.	Other States.	Totals.	Value.	
							Total.	Per Ton.
1896.....	382,068	498,400	7,418	49,047	439	937,372	$2,812,116	$3·00
1897.....	333,626	543,490	7,000	121,251	2,060	1,007,367	3,022,101	3·00
1898.....	434,273	546,881	2,200	272,191	2,100	1,257,645	4,355,025	3·46
1899.....	476,238	706,677	15,000	462,561	3,000	1,663,476	6,350,144	3·82
1900.....	414,034	642,321	17,500	450,856	3,000	1,527,711	5,375,956	3·52

(*a*) The figures for 1899 are based on railway and export shipments, except those for Tennessee, which were furnished by the Commissioner of Labor and Inspector of Mines. In 1898, 1897 and 1896 the statistics were compiled partly from shipments and partly from direct reports of the producers.

Prices.—The Florida industry felt the decreased foreign demand very keenly, as the export trade is by far the most important. In January the prices of high-grade rock f. o. b. Fernandina were $9·50@$10 per long ton, weakening in the following months to $7·50@$8·50 and closing in October at $7·50@$8. Florida land pebble was held at $4·35 per ton at Fernandina, and at $9·10@$10·85 in foreign ports. Peace River pebble was quoted at $4·50 per ton f. o. b. Fernandina in January, but fell later to $3. Quotations in the European ports ranged from $9 at the beginning of the year to $7·50 toward the close. In South Carolina the prices were better maintained as the industry is controlled by a few companies. Crude rock sold at $4·25@$4·50 f. o. b. Feteressa and dried at $4·75@$5 in January. Abroad the quotation was about $7·80 c. i. f. United Kingdom. In March prices advanced 25c. per ton, but fell later and in June the price at Feteressa was $3 for crude. During the last six months the prices ruled at $3·50@$4 for crude and $4@$4·50 for dried. Tennessee export rock sold at $2·85@$4·75 per long ton f. o. b. Mount Pleasant; domestic rock sold at $2·75@$3·75 for 78%, $2·50@$3·25 for 75% and $2·25@$2·75

for 65 to 72%. In the foreign markets high-grade rock brought $9·36@$11·70 per long ton c. i. f. United Kingdom, Baltic, Mediterranean and North Sea ports, according to time of delivery.

Shipments.—The foreign and domestic shipments of phosphate rock are given in the subjoined tables:

SHIPMENTS OF PHOSPHATE ROCK. (IN TONS OF 2,240 LB.)

States.	1898.			1899.			1900.		
	Foreign.	Domestic.	Total.	Foreign.	Domestic.	Total.	Foreign.	Domestic.	Total.
South Carolina.....	64,175	364,881	429,056	94,921	432,187	527,108	63,500	389,500	453,000
Florida.....	430,993	123,225	554,218	583,132	88,321	671,453	410,000	120,000	530,000
Tennessee.....	70,000	202,191	272,191	163,114	277,447	440,561	135,000	280,000	415,000
North Carolina....	*Nil.*	2,200	2,200	*Nil.*	15,000	15,000		17,500	17,500
Pennsylvania.....		2,100	2,100	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil*

YEARLY SHIPMENTS OF HIGH-GRADE FLORIDA PHOSPHATE ROCK. (IN TONS OF 2,240 LB.)

Countries.	1897.	1898.	1899.	1900.	Countries.	1897.	1898.	1899.	1900.
	Tons.	Tons.	Tons.	Tons.		Tons.	Tons.	Tons.	Tons.
Austria	4,505	4,946	(c)	5,922	Italy.....	16,931	11,040	4,546	(c)
Belgium....	22,954	38,903	37,103	31,639	Norw'y & Sweden	7,442	9,378	11,938	8,000
Denmark ..	11,019	8,287	5,475	2,930	Russia	3,613		1,700	2,702
England....	24,163	23,849	31,789	20,542	Scotland.....	5,957	6,000	9,545	1,790
France.....	13,931		3,165	(c)	All other (b).....	2,415	3,642	8,360	6,408
Germany...	181,355	186,731	243,887	208,422					
Holland (a).	53,039	64,309	87,167	54,349	Total.....	350,277	360,505	444,675	348,556
Ireland	2,953	3,420	(c)	5,852					

(a) A large proportion of the shipments to Rotterdam is forwarded to the interior of Germany. (b) Included in these shipments are those made to the United States, Australasia, Japan, Spain, and the West Indies. (c) Not reported.

Imports and Exports.—The total imports of phosphate rock in 1900 amounted to 138,039 long tons, valued at $794,944 as against 115,913 long tons, valued at $523,258 in 1899. The total exports of phosphate rock in 1900 amounted to 620,070 long tons, valued at $5,217,946, against 868,513 long tons ($6,778,820) in 1899. The exports of Florida high-grade rock were 348,556 long tons in 1900 against 444,675 long tons in the preceding year.

THE WORLD'S PRODUCTION OF PHOSPHATE ROCK. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Algeria.		Belgium. Cubic Meters.		Canada.		France.		Norway.	
1894.....	64,260	$230,888	371,776	$879,300	6,224	$ 41,166	539,000	$3,311,142	2,086	$36,460
1895.....	157,886	634,323	506,730	683,140	1,653	9,565	526,784	3,160,600	1,601	23,760
1896.....	165,738	500,905	297,470	537,320	517	3,420	582,667	3,502,027	1,106	17,280
1897.....	223,141	912,564	350,056	436,762	824	3,984	535,390	2,852,887	c 872	12,960
1898.....	269,500	1,078,000	156,920	303,230	665	3,665	568,558	3,115,958	3,593	53,352
1899.....	324 983	1,299,932	190,090	342,180	2,722	18,000	645,868	3,334,145	(e)	(e)

Year.	Redonda. Br. W. Indies. (d)		Russia. (b)		Spain. (b)		United Kingdom.		United States.	
1894.....	579	$5,525	14,072	$31,680	40	$80	711	$6,385	1,098,147	$3,296,602
1895.....	5,778	24,880	6,327	18,682	1,040	2,081	2,540	21,875	1,116,247	3,296,004
1896.....			3,776	11,065	770	3,080	3,048	26,250	952,370	2,812,116
1897.....	812	5,525	5,917	22,132	2,084	16,672	2,032	17,500	1,023,485	3,022,101
1898.....	750	4,725	(e)	(e)	4,500	46,003	1,575	13,565	1,257,645	4,355,025
1899.....	(e)	(e)	(e)	(e)	3,510	35,100	1,469	12,645	1,663,476	6,350,144

(a) From the official reports of the respective countries and *Annual General Reports on the Mineral Industry of the United Kingdom*, by C. Le Neve Foster. (b) Phosphorites exported. (c) Apatite exported. (d) Aluminum phosphate exported. (e) Statistics not yet published.

Algeria.—The industry is controlled by a combine of the leading producers, which includes the Compagnie des Phosphates du Dyr, La Société des Phosphates de Tébessá, La Société Française des Phosphates de Tocqueville and the Constantine Phosphate Co., Ltd. The last mentioned, which operates at Djebel Kouif alone produces about 120,000 metric tons per annum. All of the mines have railway connection with the sea coast and owing to their favorable situation and high quality of the product, are strong competitors of American rock in European markets. The shipments from Bonê, Algeria in 1900 were 232,353 metric tons, against 246,406 in 1899.

Belgium.—This country is an important producer of phosphate rock, which is converted by domestic manufacturers into superphosphate and in part exported to neighboring States. Belgium has great advantages in this field over most of the European countries, owing to its favorable situation as regards transportation, cheap fuel and labor, and especially the low cost of sulphuric acid which is recovered as a by-product at the zinc smelters. It is stated that 60° acid is delivered at the works at a cost of from 1·60 to 1·75 fr. per 100 kg., or $2·80 to $3·07 per short ton.

Christmas Island.—Trial shipments of phosphate rock were made to European ports, but owing to the high freight rates the field cannot compete at present in this market with the Algerian and American phosphates. The deposits are very extensive and average, it is stated, 86% calcium phosphate, occasionally running as high as 92%. An official analysis of a consignment to Hamburg shows calcium phosphate 85·76%, iron and alumina 1·73%, water 2·10%. It is reported that large sales have been made for shipment to Australia and Japan.

Egypt.—According to the report of the German consul at Cairo, extensive deposits of phosphate rock have been found in the desert east of Kenah near the caravan route leading to Kosseir on the Red Sea, and also in the Dakleh oasis of the Libyan Desert. The rock is said to be exposed in many places and can be worked without much difficulty. Analytical tests show the presence of phosphoric acid in amounts corresponding to 40 to 60% calcium phosphate, which is too low to permit of the material being exported, although it may be of domestic importance.

France.—The production of phosphate rock, which amounted to 645,868 metric tons in 1899, is exceeded only by that of the United States. The most productive fields are located in the departments of Somme, Pas-de-Calais, Aisne, Oise and Meuse, the department of Somme alone producing about 300,000 tons. Deposits are also known to occur in the Pyrenees Mountains, and will probably be exploited in the near future. Specimens from this region, according to David Levat, show 60 to 77% tribasic calcium phosphate. Among the European countries, France is the largest manufacturer of superphosphate and also the largest consumer; in 1899 the total output was about 950,000 metric tons, and the consumption 980,000 tons.

Germany.—The consumption of superphosphate in Germany amounts to about 825,000 metric tons, a small portion being imported. The crude material is derived mostly from the United States and Algeria.

Tunis.—The production by the Compagnie des Phosphates et du Chemin de

Fer de Gafsa, which exploits the deposits at Gafsa, in 1899 was 70,000 metric tons. The output in 1900 increased largely, amounting to 83,000 tons during the first six months. A new field is about to be opened on the plateau of Kalaa-es-Senam near the Algerian frontier, the rights of exploitation having been sold in December of last year. The deposits range in thickness from 12 to 15 m., of which about 2 m. is high-grade rock. An average analysis shows 60% calcium phosphate, 25% calcium carbonate, 0·25% iron oxide and 0·50% alumina. The distance from the mines to Tunis, the nearest port is about 250 km., and the two points are to be connected by a prolongation of the railway from Tunis to Pont de Fahs.

Progress in the Phosphate Mining Industry of the United States during 1900.

By C. G. Memminger.

Arkansas.—Phosphate rock has been found in several parts of Arkansas although but little systematic prospecting seems to have been done. A majority of samples tested show low phosphoric acid and high iron and aluminum oxides. The following is an analysis of a sample recently received: Phosphoric acid, 34·17%; (bone phosphate of lime, 74·57%); iron oxide, 0·84%; aluminum oxide, 3·78%.

Florida.—While phosphate rock exists from the extreme northern portion of the State to Lake Okeechobee in the south, a distance of 240 miles, and of an average width of territory 30 miles, the deposits occur only at widely scattered points and those of commercial value form but a very small percentage of the total phosphate-bearing area. The grades of product mentioned in the order of their commercial importance are, hard rock, land pebble and river pebble.

The hard rock industry attained its maximum output in 1899, producing 444,675 tons. In 1900 the production was 343,120 tons, a decrease, due in part to low prices and high ocean freight rates. It is mined in a territory extending from Albion to Bay City, 90 miles south, and from 8 to 10 miles in width. The deposits are simple pockets yielding from a few tons to many thousands, hence the mining plants are scattered and their location changed as the pockets become exhausted. In the early days of the industry the so-called boulder rock was the sole material mined. The boulders varied in weight from a few pounds to many tons. Originally the mining consisted in removing the overburden, raising the rock from the pits, drying it in kilns and shipping it without further preparation. Under the conditions of small capital involved, high prices and large profits, many hard rock mining companies were formed, only to find that the deposits easy of extraction were few in number. Attention was then directed to the gravel phosphate which represented the smaller or broken pieces of rock. This rock occurs intermixed with clay, flint, etc., the latter being removed in the ordinary log washer. As the mining and milling became more complicated and costly, large central plants were erected for cheaper treatment cost. The economy sought, however, was not realized owing to the small size of the individual deposits and the consequent expense in transporting the crude material

containing but from 12 to 15% phosphate from the mines. The present accepted methods of cheapest treatment is to have one or more removable washing plants, each of a capacity of from 40 to 50 tons of clean rock in 12 hours. These are so constructed that they may be easily taken down and removed to new localities. Generally the greatest expense of these moves is the drilling of a well to supply washing water. It is also the present practice to crush the entire product of the mine and pass it through the washers, producing a more uniform product. The method of operation consists in passing the crushed material through log washers and screens, liberally supplied with water, which removes the clay, sand and fine material. The washed rock passes to a "picker belt" and is carefully hand sorted. It is then dried in kilns. For this last operation 5 cords of light wood, or 7 cords of ordinary pine are required per 100 tons of rock. The product is then ready for shipment. The average cost of production, ready for shipment at the mines, is from $3·50 to $4 per ton. Those deposits most favorable for cheap transportation and mining have already been largely exhausted and the present efficient methods of mining and handling leave but little room for diminishing the costs, consequently with the gradual exhaustion of the best deposits production costs must increase. Probably the present cost f. o. b. at the mine is as low as it will ever be. The cost to the consumer, however, is largely regulated by the cost of transportation from mines to port of shipment. The Dunnellon Phosphate Co. has constructed a railroad and is dredging a channel at Port Inglis. Hard rock is sold on guarantee to contain a minimum of 77% bone phosphate of lime and a maximum of 3% iron and aluminum oxides; the highest grade runs to 80% bone phosphate of lime and from 2 to 3% iron and aluminum oxides. Practically the entire hard rock product is exported, Germany being the largest consumer. The ports of shipment are Fernandina and Port Tampa, Fla., and Brunswick and Savannah, Ga. With regard to the available reserves of hard rock it is impossible to form even an approximate estimate. At the present rate of production there need be no fear of exhaustion for some time to come, still the best grade product is limited in quantity.

The production of land pebble phosphate, which began in 1891, amounted to 230,886 tons for 1900. From various causes a number of the mining plants were shut down during 1900 and practically the entire number were run on half time. The deposits are located in Polk, De Soto and Hillsboro counties in central southern Florida and are contained in an area approximating 2,000 sq. miles, beginning 4 miles north of Bartow and extending over the upper portion of the drainage basin of the Peace and Alafia rivers. At present no land pebble is being mined in De Soto or Hillsboro counties. In the former it is of too low grade and in the latter the deposits are too small. While the restricted area and widely scattered deposits render land pebble phosphate of comparatively less importance, yet individual deposits often are capable of producing several hundred thousand tons. The pebble occurs roughly rounded and of grayish or brownish color, varying in size up to 2 in. in diameter. In preparing the material the smaller and larger particles are separated, leaving a product varying in size from 0·0625 to 1 in. in diameter. The deposits usually occur along the stream courses or in low swamps or bay heads. The beds vary from a few inches to

18 ft. in thickness, averaging 10 ft. for the district. The pebble occurs in an argillaceous matrix, occasionally very sticky and tenacious and sometimes sandy and readily disintegrated. The pebble usually represents less than 25% of the mass. The beds are covered with an overburden consisting of sandy soil, clay, hard pan or so-called "conglomerate" rock varying in character in different parts of the deposit. The bed rock varies from a hard yellow marl to a soft clay-like material. The highest grade contains 68 to 73% bone phosphate of lime and from 3 to 4% iron and aluminum oxides; low grade, 65 to 67% bone phosphate of lime and 4 to 5% iron and aluminum oxides. Land pebble is now sold on a guarantee of minimum 68% bone phosphate of lime and a maximum of 4% iron and aluminum oxides. Under existing conditions to work a land pebble deposit profitably calls for an average minimum yield of clean dry pebble to mass 20%; an average minimum thickness of deposit, 8 ft., yielding 3,733 tons per acre, and an overburden not exceeding the thickness of the deposit.

The present method of hydraulic mining for treating land pebble was introduced by W. F. Lay and is undoubtedly the only practical method of mining this class of rock. The important feature is, that the water used in breaking down the rock partially disintegrates the matrix and separates the pebble, which renders the subsequent washing operation a comparatively simple problem. A mining plant consists of a steam shovel for the removal of overburden, one or more dredges fitted with the following machinery: 400 to 500 H.P. boilers, 10-in. centrifugal pump, hydraulic pressure pumps, screens, washers, and barges to transport the pebble to the mill. The mill should contain efficient washers, rotary dryers, elevators, boilers and dry storage bins of from 4,000 to 15,000 tons capacity. This equipment calls for a heavy investment. A plant with one dredge and two dryers should produce 50,000 tons per year. The method of mining is briefly outlined as follows: The overburden having been removed by steam shovel, the dredge is launched in suitable excavation and the suction pipe from the centrifugal pump on the dredge is laid some 150 ft. in advance and a small sump hole is opened for suction. Streams of water from two hydraulic giants working under a pressure of 100 to 110 lb. per sq. in. are directed into the hole, which is increased to a considerable size in a short time. The suction gradually becomes lowered until the sump is formed in the bed rock. As soon as possible the giants are placed in the pit and as the banks are cut down the material passes with the water to the sump and is pumped to the dredge where it is screened, the pebble being thoroughly washed and separated and the debris discharged at the side of the dredge. As the pit becomes enlarged it is good practice to use a second centrifugal pump in connection with the pump on the dredge. In this way a pit of several acres' extent can be mined. The pump and pipes are removed from the pit as soon as economy in pit size is reached. The pit is filled with water and the bank between the dredge and the pit broken. The dredge is then moved on and operations begin afresh. The pits form a channel for the transportation of the pebble in barges. On reaching the mill the pebble is elevated, thoroughly washed, dried and stored for shipment. The most modern plant in this district has introduced electric motive power

and proposes to eliminate the dredge by making a series of electrically driven centrifugal pumps which will force the entire material mined to the mill; a central pumping station giving the hydraulic pressure required. Under certain conditions this system promises excellent results.

The highest grade deposits with light overburden and greatest yield per acre are fast being exhausted, and fuel—a large item of cost—is rapidly being exhausted in the immediate vicinity of the mine. The present cost of production f. o. b. at the mines, is from $1·50 to $2 per ton, a figure that will doubtless increase very materially in the near future. The product is shipped from Port Tampa. At the present rate of production the deposits containing 68% and upward of bone phosphate and low in iron and aluminum oxides, will be exhausted within a few years. Those containing 64 to 67% bone phosphate and 4 to 6% iron and aluminum oxides are in very large reserves.

River pebble was first shipped in 1888. It occurs in Peace, Alafia, Mioha and Caloosahatchee rivers, but in the Peace River basin only is it of sufficient grade and quantity to be of commercial importance. The river pebble is derived from the washing down of the land deposits along the head waters of the rivers and is found in the river beds proper and in low adjoining swamp lands. The pebble with intermixed sand is raised by a centrifugal pump that is mounted on a small dredge and the screened pebble discharged into small barges at the side of the dredge, the sand passing over the stern of the dredge. The pebble is carried to the mill, where it is dried and passed through screens to eliminate any remaining sand. It is then ready for shipment. The deposits are irregular and pockety and, for successful treatment by a centrifugal pump, the pebble must occur in loose sand with an overburden practically free from clay.

The Peace River pebble contains from 60 to 62% bone phosphate of lime and 2 to 3% of iron and aluminum oxides. The Peace River bed proper is exhausted, the mining now being carried on in the old river courses and in the low land on either side of the river channel. Under present methods of extraction the amount of pebble available is rather limited and can only be increased by the development of new mining methods for the treatment of deposits occurring with clay in or over them. The cost of mining varies from $1 to $1·50 per ton at the mine. The river pebble is shipped from Punta Gorda, Fla., and amounted to 54,506 tons in 1900, distributed as follows: Foreign, 21,427 tons; domestic, 33,079 tons. The entire product is mined by the Peace River Phosphate Mining Co.

South Carolina.—Phosphate rock in this State is known as land rock and river rock, the former occurring in the vicinity of Charleston, and the latter in the Cowsaw River and other streams in the vicinity of Beaufort. The rock contains from 57 to 60% bone phosphate of lime. The land rock containing a higher percentage of iron oxide and alumina than the river rock has been practically consumed by the home market. The river rock, low in iron and aluminum oxides has mainly been shipped abroad and is still an acceptable product in the English market. The excellent quality of the phosphate rock of South Carolina, together with the favorable shipping conditions, places the production on a permanent basis and its mining will cease only with the exhaustion of the

deposits. There is probably a sufficient supply at the present rate of production to last 35 years. The output of phosphate rock, especially of river rock, has decreased markedly since the development of the Florida and Tennessee fields. Methods of mining and preparation have not changed materially during the past 10 years except that steam shovels are taking the place of hand labor for the removal of the overburden and the mining of the land rock. The competition from the Florida and Tennessee companies has called for a reconstruction of South Carolina business and only the stronger concerns survived. Even with the present sharp competition and low prices, the South Carolina phosphate mines, if properly handled, will pay fair returns.

Tennessee.—Tennessee phosphates are divided according to their color into blue, brown and white rock. The blue rock deposits began to be developed in 1894. They are situated in Lewis and Hickman counties, the principal beds being found adjacent to Swan Creek valley. The area of the beds is approximately 10×20 miles. The lack of railroad transportation renders the development of these deposits slow as much of the material has to be conveyed by wagon several miles. At present, the most valuable section of these deposits is too far from transportation to be available and 20 miles of railroad are necessary to render their development commercially profitable. The discovery of more favorably located and higher grade brown rock deposits at Mount Pleasant reduced the mining of the blue rock to small proportion. Blue phosphate rock occurs in horizontal beds lying on and conforming to the country limestone. Above it is a black Devonian shale. The phosphate beds vary in thickness, averaging 18 inches for the workable deposits. The phosphate beds are exposed along the valley sides only where the stream courses have cut through the overlying strata and in a few favorable places it can be mined in open cuts by stripping the overburden. The great bulk of the rock, however, must be mined under cover and with an 18-in. seam the mining cost is high. While preparation and cleansing will improve the grade it is not essential to do so and the high cost of mining is largely offset by the reduced cost of preparation. In fact, this is the only phosphate deposit as yet found in the United States that can be mined and shipped without treatment. The average of the blue rock shows 70% bone phosphate of lime, 2·5 to 3% iron and aluminum oxides. On account of its location the output is limited to domestic consumption.

It is impossible to estimate, even approximately, the extent of the deposits. Suffice to say that it is large. With this blue rock occurs a so-called brown rock which analyzes 74 to 75% bone phosphate of lime and from 5 to 6% iron and aluminum oxides.

The brown rock phosphate deposits at Mount Pleasant, Maury County, cover an area of 3×8 miles, but do not occur in a continuous bed. The rock is of brownish color, porous texture and occurs in strata of varying thickness. The phosphate bed conforms to the irregularities of the underlying limestone and is 36 in. average thickness, and the overburden consists of loamy soil and is of varied thickness. The average yield per acre is 4,000 tons. In mining, the overburden is removed and the phosphate rock extracted by hand with pick and bar. Large pieces are separated and two classes are made, known locally

as domestic and export. The run of mine, after removal of export lumps, is washed, kiln dried, crushed and screened, the small particles of dust passing through being classed as domestic; the larger lumps discharged from the screen being exported. The object in crushing and dry screening is to get rid of the argillaceous matter high in iron and alumina, that adheres to the rock. As the rock is porous and the clay baked on it in the kiln drying, the dry separation is by no means efficient and the high percentage of iron and aluminum in this rock is largely due to the crude method of preparation. Experiments conducted under my supervision have proved that the crushing of the rock to small size previous to drying followed by a thorough washing produces a grade equal to the best Florida hand rock and can be sold on a guarantee of 80% bone phosphate of lime and a maximum of 3% of iron and aluminum oxides. The Mount Pleasant rock is classed into (1) export with a guarantee of 78% minimum bone phosphate of lime and 4% maximum iron and aluminum oxides and (2) domestic, guaranteed 75% bone phosphate of lime and 5% maximum iron and aluminum oxides. A considerable amount of the Mount Pleasant rock is simply mined and kiln dried.

The white rock deposits occur in Perry County, the largest development being on Tom's Creek. It is far from railroad communication, but is within 4 miles of the Tennessee River, which affords water transportation. The rock closely resembles Florida land rock in appearance and occurs along with chert in pockets of variable size. No other large deposit of this class has been so far developed. Selected samples show high percentage of bone phosphate of lime and low percentage of iron and aluminum oxides. On account of its unfavorable location but little development work has been done. Other discoveries of phosphate rock have been reported from numerous localities and mining is carried out in a small way at one or two places, but no discoveries of any importance are to be noted.

PLATINUM AND IRIDIUM.

During 1900 there were produced from domestic sources 173 oz. platinum and 8 oz. iridium as compared with no production of platinum and 5·6 oz. iridium in 1899. The domestic production of platinum in past years was obtained at the San Francisco mint from parting and refining gold from certain localities in Trinity, Shasta and Plumas counties, Cal., and from British Columbia. In addition a small quantity was derived in the refining of nickel matte from the Sudbury district, Ontario.

During the past two years several discoveries of platiniferous deposits have been reported from Caconde, Rio Pardo, Brazil; Sonora, Mexico and on the Hootalinqua River in the Yukon Territory, Canada, but as yet no appreciable quantity of the metal has resulted. Of these, the last named locality is the most promising. A discovery of osmiridium has been reported from the South Sea Islands, and it is stated that the deposit will be exploited by a German and an American company.

The imports into the United States during 1900 were valued at $1,762,020, against $1,537,910 in 1899, a considerable part of which is in crude form, the metal being refined here. The prices quoted in the New York market toward the close of the year were $18·20@$18·50 per Troy oz. for ingot platinum in large quantities and 72c. per gram for crucibles, hammered ware and wire. In London, unmanufactured platinum brought 75s. and crucibles, etc., 77s. 6d.@80s. per oz.

The world's annual production of platinum for the past few years has ranged between 160,000 and 170,000 oz. and for 1900, the total as far as ascertained approximates 165,000 oz., of which Russia supplied about 153,000 oz. The output is sufficiently below the demand to cause the price to approach that of gold.

Alaska.—The discovery of a platiniferous deposit in the Copper River district was reported in 1900. Its value is stated to range from $13 per ton at the surface to a markedly higher amount as the depth increased.

Canada.—According to the Annual Report of Mines and Minerals, 1900, the reported production of platinum in 1899 from the Similkameen River, Yale district, B. C., was 55 oz., although some unrecorded amounts were produced at Quesnel, North Bend and other places. In 1900 the Yale district produced 70 oz. The value of the crude platinum sand when washed out from the "black sand" that has been rejected as worthless by the miners varies from $12 to $15 per oz. The sand is frequently magnetic and a separation from the iron sand cannot be effected by a magnet.

An analysis of the mineral sperrylite from Vermillion Lake, Denison, Ontario, by Prof. H. L. Wills, of Yale, gave: As, 40·98%; Sb, 0·5%; Pt, 52·57%; Rh, 0·72%; Pl, trace; Fe, 0·07%; SnO_2, 4·62%.

Colombia, S. A.—The output of Colombia is about 11,500 oz. annually, and while an increased production was expected in 1900 the prolonged revolution has prevented any extension of the mining industry.

Ecuador.—Platinum in variable quantities is found in the washings of the Esmeraldas placer deposits. An analysis of one sample is quoted as follows: Platinum, 84·95%; palladium, rhodium, iridium, 4·64%; iron, 6·94%; gold, 1·12%; osmiridium, 1·54%; sand, 0·81%; copper and silver, traces.

New South Wales.—The production in 1899 was 638 oz., valued at £1,070, against 1,250 oz., valued at £2,062 in 1898. The diminished yield was partly due to the great scarcity of water. The output was mainly from the Fifield gold district, where it occurs with the gold in the wash dirt as coarse shotty grains of greater purity than that obtained from the Northern beach sands. A special lease has been applied for to work the abandoned ground at McAulay's Lead, Jerusalem Creek, it being the intention to save the platinum which collects in the concentrates. In the Bullahdelah division the presence of osmiridium in large quantities was reported. This is regarded as a good indication that platinum exists there as well.

Russia.—There has been no material change in the industry in Russia during the past year, although the business is gradually passing into the hands of a combination of the mine owners and of Belgian and French refiners which was founded in 1898. This syndicate, which controls the platinum working establishments of the Oural, has recently erected two refineries at Ekaterinenburg and the export of crude platinum from Russia will probably cease. The syndicate has also secured the crude platinum held by Count Schuvalov and P. P. Demidov so that the works will handle about 300 poods of crude platinum annually. Almost three-quarters of the Russian production is sent to the United States.

Tasmania.—A small quantity of osmiridium was produced during 1900 from the Savage River sands which yielded a few pounds per month.

Notes on the Occurrence of Platinum in North America.

(Abstracted from a paper by David T. Day, read before the American Institute of Mining Engineers, February, 1900.) While isolated finds of platinum in small quantities have been reported in certain States on the Eastern seaboard the only deposits now known in North America where this metal occurs in commercial quantities are in California, Oregon and British Columbia.* On the Pacific Coast there are platinum deposits at Santa Barbara, at Lompoc in San Luis Obispo County, at Santa Cruz, between Santa Cruz and the Golden Gate, and in Humboldt and Del Norte counties. The beach mines of Gold Bluff, north of Arcata, Big Lagoon, Stone Lagoon, Little River and at Crescent City in California and of Gold Beach and Port Orford in Coos County, Ore., have all yielded platinum in commercially appreciable quantities. Still further north the metal is found at Yaquina Beach, Ore., but the sands there are poor. The richest beach is probably at Port Orford. Of the California placer deposits those in the Bee Gum district in Shasta County, Hay Fork district, Trinity County, and along the Trinity River, are the most promising. In the Bee Gum and Hay Fork districts and at Chapman's mine on the Trinity River, osmiridium comprises the greater part of the mixture of platinum metals and Dr. Shapleigh

* During 1899-1900 platinum was extracted and refined by the Orford Copper Co. from the Sudbury nickel copper mattes.—Editor of The Mineral Industry.

found that Pacific Beach platinum often contained more than 90% of osmiridium. This explains the fact that little effort has been made to mine platinum, for until recently, the osmiridium has had but little value.

From the placer sands of Tulameen Fork, B. C., Dr. Day could obtain no osmium, although Dr. Hoffman, of the Canadian Geological Survey, has found samples that contained as high as 25% with an average of 10% osmiridium.

To determine the value of the deposits, samples of heavy sands, averaging 4 lb. each, were collected from more than 60 placer mines in California, Oregon, Washington, Idaho, Montana and Alaska. These were sieved into nine lots, coarser than 20-mesh, through 20-, 40-, 60-, 100-, 120-, 160-, and 200-mesh. The highly magnetic portion was separated by a crude separator which removed but very little of the gold or platinum. Each size was panned and the gold and platinum were determined by counting the flakes or by weighing, which gave a fair idea of the proportion of platinum to gold and the total weight of the metals as well. The results showed that if all the sands examined were considered together, there would be about half as much of the platinum metals as of gold. Of four samples from different localities in California the one from Happy Camp indicated a value in platinum metals of $50·97 per ton; that from China Flat, $177·08 per ton; of Crescent City, South Forks, Smith River, $681·31, and of Junction City, $1,934·18 per ton. None of the specimens from the other States named showed values in platinum at all comparable with these, although many of them indicated the presence of the metal in commercial amounts.

Technology and Uses.

There has been little or no radical change during the past five years in the process of refining and handling platinum. The metal is refined in the United States by the Mint; Baker & Co., Newark, N. J.; C. F. Croselmire, Newark, N. J.; the S. S. White Dental Mfg. Co., Prince's Bay, N. Y., and the Orford Copper Co., Constable Hook, N. J. The following notes relating to the chemical analysis and physical properties of platinum have been summarized from the technical literature that has appeared during the year.

New Method of Separating the Platinum Metals.—E. Leidié* has suggested a method for the separation of the metals of the platinum group which is based on the properties of the double alkaline nitrites of these metals, somewhat similar to that of Gibbs. As described it is apparently too long for practical or commercial use. For full details reference may be made to the original article or to the abstract which appeared in the *Journal of the Society of Chemical Industry,* January 31, 1901.

Solubility of Platinum when in the Form of an Alloy.—Dr. H. Rossler† offers some data concerning the solubility of platinum and other metals when in the form of alloys. In platinum-silver alloys which contain a large proportion of silver, the platinum is partially soluble in nitric acid. The residue is not metallic platinum, but an oxidized form which is soluble in hydrochloric acid. According to A. Von Ropp the very large proportion of silver as compared with that of platinum influences the solubility of the latter metal. The platinum

* *Comptes Rendus* 131, (22) p. 888–891. † *Chemiker Zeitung*, Aug. 29, 1900.

and portions of the gold found in the slimes from the Moebius electrolytic parting process, are also soluble in hydrochloric acid, and are in chemical combinations containing oxygen and nitrogen. Platinum in bullion containing not more than 2% Pt may be estimated by dissolving separate portions in nitric acid and sulphuric acid, and observing the difference between the weights of the residues. Rhodium in alloys with gold exhibits peculiarities analogous to those of platinum in platinum silver alloys, an alloy containing not more than 1% Rh dissolving completely in aqua regia. Rhodium does not alloy with pure silver.

Improved Gooch Crucible.—W. C. Heraeus* describes an improved form of the Gooch crucible, which consists in covering the bottom with platinum sponge, instead of asbestos. The finely divided metal is said to filter as well as filter paper, and is very durable and easily cleaned. The inventor, Neubauer, has found the platinum filter in a crucible of this kind practically unchanged after having been used in more than 100 estimations.

Loss in Weight of Commercial Platinum.—Robert W. Hall† has investigated the cause of the loss in weight of commercial platinum, and found that it was due to the chemical action of oxygen which removed certain elements.

Deterioration of Platinum and Its Alloys at High Temperatures.—In the measurement of high temperatures by means of the thermo-electric couple composed of two wires, one of platinum and the other an alloy of platinum with either rhodium or iridium, H. le Chatelier‡ has found the cause of the deterioration of the wires when unprotected. All volatile metals attack platinum and its alloys under the influence of the heat necessary for volatilization. Zinc, antimony, copper and silver emit sufficient vapor at the temperature of fusion to attack the wires of couple and as these vapors excepting silver can only exist in a reducing atmosphere, it is necessary when making high temperature measurements with the exposed couple, to avoid a reducing atmosphere when they are present. The vapors of the metalloids phosphorus and silicon are particularly dangerous to the safety of the couple, and while they are rarely found uncombined, their oxides at a high temperature are completely reduced in a reducing atmosphere. Phosphoric acid as well as metallic phosphates and basic phosphates of all reducible acids should be guarded against. In like manner, silicon is reduced from silicates, especially those that are present in clay. For this reason a reducing flame in a refractory fire-brick furnace will cause a gradual destruction of the wires.

The Determination of Iridium in Alloys.—W. Mietzschke§ recommends the following method of analysis for alloys of gold, silver, iridium and platinum with or without base metals. The alloy is refined and separate portions treated with nitric and sulphuric acids, the portion dissolved serving for the estimation of silver and platinum. The residue of gold and iridium is treated with aqua regia, and the gold precipitated with ferrous sulphate and weighed. The iridium is determined by collecting the residue remaining after dissolving the gold, the particles carried mechanically in the solution of silver and platinum, and the portion remaining in solution after precipitating the gold.

* *Zeitschrift für Angewandte Chemie*, 1900, 745.
† *Journal of the American Chemical Society*, August, 1900.
‡ *Mesure des Temperature Élévée*, Paris, 1900.
§ *Berg- und Hüttenmannische Zeitung*, Feb. 9, 1900

POTASH AND POTASSIUM.

THE world's supply of potassium salts, with the exception of saltpeter, continues to be derived from Germany, where the production is controlled by the Kali-Syndicate which was organized by all the active mines for the protection of common interests and especially to avoid overproduction. The agreement first entered into in 1879 has been renewed and revised from time to time. The last renewal dates from June 22, 1898, was amended on June 29 of that year, and is to run until December 21, 1901. According to this agreement the marketable products are divided into three classes: (1) Crude salt, that is, potassium and magnesium products direct from the mines, not including boracite; (2) manufactured products, so far as they are prepared in the chemical works connected with the mines; (3) mixed salts, mixtures of crude and prepared salts, for fertilizers.

The Kali-Syndicate by its agreement determines not only the sale and the prices of the different products but it has also decided the exact amount which each mine may contribute to the total output. In this connection the products of the mines are divided into four classes, according to their percentage of potassium, as follows: (1) Products with more than 48% K_2O, an equivalent of 76·1% KCl or 88·9% K_2SO_4. (2) Products with not more than 48% K_2O nor less than 18%, equivalents of 76·1 to 28·5% KCl or 88·9 to 33·3% K_2SO_4. (3) Crude salts (not carnallite) with 12·4 to 18% K_2O, equivalents of 19·7 to 28·5% KCl or 23·0 to 33·3% K_2SO_4. (4) Carnallite salts with less than 12·4% K_2O. The percentage of potash is made the basis for determining the amount of salts of each kind which any manufacturer may offer for sale, but no restrictions are put on the output of the crude material so long as it does not come into the market. Class 1 includes mostly refined products; class 2, both refined and crude; classes 3 and 4, crude only. A method for separating classes 3 and 4 was adopted, and will prevent carnallite salts which contain a high percentage of potash being sold under class 3. It is based on the relative solubilities of carnallite and kainite in 96% alcohol, the magnesium chloride in the kainite being insoluble, while it is soluble when occurring in carnallite. Salts which contain more than 6% soluble chlorine are put in class 4.

The quota assigned to each member of the Syndicate is shown in the following table, which also gives their relative importance. The figures in each column

represent the contribution of each mining company per 1,000 metric tons of total output:

Name of Mining Companies.	Class I.	Class II.	Class III.	Class IV.
Der koeniglich preussicher Bergfiscus.....	130	130	130	142
Der herzoglich anhaltische Landesfiscus..	118	118	120	110
Westeregeln.....	100	100	102	100
Neu-Stassfurt.....	100	100	102	100
Aschersleben.....	100	100	102	100
Ludwig II.....	72	72	26	80
Hercynia.....	93	93	101	100
Deutsche Solvay-Werke.....	100	100	102	100
Thiederhall.....	46	46	*Nil.*	48
Wilhelmshall.....	61	61	85	70
Glueckauf.....	40	40	70	*Nil.*
Hedwigsburg.....	40	40	60	50
Total.....	1,000	1,000	1,000	1,000

The works belonging to the Syndicate are supplied with 513 boilers representing 53,250 H.P. and 738 engines of 47,420 H.P. The personnel consists of 818 officers and 15,570 laborers.

A company has been formed to prospect for potassium salts in the United States. It is believed that deposits of potassium salts exist in certain localities and should they be discovered their value will be very great.

Imports.—The imports and exports of potassium products of the United States are given in the tables at the end of this volume.

The statistics of the Stassfurt salt industry for the past five years are given in the following tables, which were kindly furnished by the Verkaufssyndikat der Kaliwerke, Leopoldshall-Stassfurt, commonly referred to in the trade as the "Kali-Syndicate." Statistics from the beginning of the industry in 1857 to 1895 inclusive are given in detail in THE MINERAL INDUSTRY, Vol. VIII., pp. 480 and 481.

KALI-SYNDICATE OUTPUT OF CRUDE SALTS OF ALL KINDS. (IN METRIC TONS.)

Year.	Rock Salt. NaCl.	Carnallite. $KCl, MgCl_2+6H_2O$.	Kieserite. $MgSO_4+H_2O$.	Sylvinite. KCl.	(*a*) Hartsalz, Schoenite and Kainite.	Boracite. $Mg_7B_{16}O_{30}Cl_2$.	Total.
1896...	277,884	856,223	2,841	90,390	833,025	195	2,060,558
1897...	288,036	851,272	2,619	84,105	1,012,186	184	2,238,402
1898...	291,591	990,998	2,444	94,270	1,120,616	252	2,500,171
1899...	310,378	1,317,948	2,066	100,653	1,063,195	155	2,794,395
1900...	(*b*)	1,697,803	2,047	147,791	1,189,394	223	3,037,258

(*a*) Hartsalz, NaCl, KCl, $MgSO_4+H_2O$; Schoenite, $K_2SO_4, MgSO_4+6H_2O$, Kainite, $KCl, MgSO_4+3H_2O$.
(*b*) No longer compiled.

UTILIZATION OF THE CRUDE POTASSIUM SALTS. (IN METRIC TONS.)

Year.	Carnallite and Rock Kieserite.				Kainite and Sylvinite (*a*) (including Hartsalz and Schoenite).			
	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.
	Germany.	Elsewhere.			Germany.	Elsewhere.		
1896.....	56,541	3,964	798,560	859,065	557,527	245,060	120,829	923,416
1897.....	58,544	5,157	790,190	853,891	668,340	295,765	132,185	1,096,290
1898.....	60,793	7,189	925,461	993,443	722,115	334,111	158,660	1,214,886
1899.....	58,677	4,611	1,256,730	1,320,018	717,637	314,869	131,342	1,163,848
1900.....	55,489	2,869	1,641,493	1,699,851	724,624	375,007	237,554	1,337,185

(*a*) Quantities of sylvinite containing more than 13% potash.

PRODUCTION OF CONCENTRATED SALTS. (IN METRIC TONS.)

Year.	Potassium Chloride. 80%	Potassium Sulphate. 90%	Sulphate. Potassium—Magnesium		Kieserite; Ground and Calcined.	Kieserite in Blocks.	Potash Manure Salt. (*a*)
			Crystalliz'd 40%	Calcined. 48%			
1896.....	155,805	13,889	1,051	4,622	211	24,987	19,253
1897.....	158,863	15,403	922	7,415	214	25,669	23,042
1898.....	174,380	17,781	914	10,535	728	19,934	24,284
1899.....	180,672	24,656	579	8,459	260	28,216	70,916
1900.....	206,471	34,255	932	12,150	358	28,508	129,863

(*a*) Quantities containing 38% potash.

MARKETS IN 1900.

United States.—The prices established by the Kali-Syndicate for the year beginning March 1, 1901, for New York, Boston and Philadelphia per 100 lb. are as follows: Muriate of potash, 80 to 85%, basis 80%, $1·80; muriate of potash, minimum, 95%, basis 80%, $1·83; sulphate of potash, 90%, basis 90%, $2·08; sulphate of potash minimum 96%, basis 90%, $2·11; double manure salt, 48 to 53%, basis 48%, $1·09; manure salt minimum, 20% potash, 62c. For Norfolk, Va., prices, add 2c. per hundred to the foregoing quotations for muriate of potash; 1·5c. for sulphate of potash and 1c. for double manure salt. For Charleston, Savannah, Wilmington, N. C., and New Orleans, La., add 3·5c. to the New York prices for muriate of potash salts, 3c. for sulphate of potash salts and 2·5c. for double manure salt. For bulk salts on basis of foreign analysis, kainite testing 12·4% potash is quoted for New York at $8·80 per ton of 2,240 lb., invoice weight at shipping port, or $9·05 actual weight at receiving port; sylvinite, 38c. per unit of sulphate of potash, invoice weight at shipping port, or 39c. per unit, actual weight at receiving port. Kainite prices for Norfolk are 30c. per ton higher than for New York, and at Charleston and other Southern ports 50c. higher, while sylvinite is 1c. per unit higher for Norfolk and 2c. per unit higher for Charleston and other Southern ports. These prices are for not less than 500 tons of bulk salts or 50 tons of concentrated salts and are based on river shipment from the mines to the seaport. For rail shipments an additional amount of 40 pfennigs per 100 kg. or 5c. per 100 lb. is required.

Germany.—The following prices for the different products in 1900 have been furnished by Dr. F. Klockmann. They include package and are f. o. b. Stassfurt:

A.—Potassium Chloride. (Prices per 100 kg. in amounts not less than 50 metric tons.)

% KCl	Marks for 80% KCl (*a*)	% KCl	Marks for 80% KCl (*a*)	% KCl	Marks for 80% KCl (*a*)
80–85	14·25	90–95	14·55	97– 98	14·95
85–88	14·35	95–96	14·75	98–100	15·15
88–90	14·45	96–97	14·85	(*b*) 98–100	15·25

(*a*) One mark = 23·8c. The prices are all based on 80% KCl; the excess is charged for at different rates according to the exact analysis of the material. Thus, 84% KCl would cost 14·25 marks plus 0·7125 marks (4% KCl at basis of 14·25 marks for 80%), or 14·9625 marks. (*b*) With not more than 0·5% NaCl.

B.—Potassium sulphate (high grade, in any amount).—For minimum of 90% K_2SO_4 and maximum of 2·5% Cl, 16·45 marks per 100 kg. 90%; for minimum of 96% K_2SO_4 and maximum 1% Cl, 16·85 marks per 100 kg. 90%.

C.—Double sulphate of potassium and magnesium (in any amount).—Calcined, containing a minimum of 48% K_2SO_4 and a maximum of 2·5 Cl, 8 marks per 100 kg. 48%; crystallized, containing a minimum of 40% K_2SO_4 and a maximum of 1% Cl, 6·40 marks per 100 kg 40%.

D.—Potash fertilizer (exclusive of package in carload lots).—For minimum of 20% pure potash, 3·10 marks per 100 kg.; for minimum of 30% pure potash, 4·75 marks per 100 kg.; for minimum of 40% pure potash, 6·40 marks per 100 kg.

E.—Kieserite, calcined and ground (in any amount).—For a minimum of 70% $MgSO_4$, 2·60 marks per 100 kg., and no additional change for an excess of that percentage.

The rapid strides made by the potash industry are evident in the statistics of production, according to which the total output of salts in 1861 was 2,293 metric tons but in 1900 amounted to over 2,000,000 tons.

Statistics of the Potassium Salts Industry of Germany.

By C. Hornung and E. C. Mackay-Heriot.

The following statistics of production and labor are taken from the *Reichsmontanstatistik*, of the German Empire, the *Montansstatistik* of the Kingdom of Prussia (*Zeitschrift für das Berg-, Hütten und Salinenwesen*) and the *Reports of the Halberstadt Handelskammer* (board of trade)* from 1874 to 1899, inclusive. The statistics referring to the output, price, number of producing works, labor, during 1875 to 1897 are divided into two groups. An extension beyond these years could not be made as previous to 1875 the *Reichsmontanstatistik* arranged the data in a different manner and the official figures for 1898 and 1899 for the whole German Empire have not been published.

The products are divided into two groups: the first group contains the mineral or crude salts: (1) rock salt; (2) kainite; (3) other potassium salts (carnallite, sylvinite and hartsalz); (4) kieserite; and (5) boracite; the second group includes those salts prepared from aqueous solutions: (6) table salt; (7) potassium chloride; (8) magnesium chloride; (9) alkaline sulphates: (*a*) glauber salts; (*b*) potassium sulphate; (*c*) potassium and magnesium sulphates; and (10) magnesium sulphate.

The total output of both crude and manufactured salts, including the amounts of the former which have been furnished to salt works and chemical manufactories, has risen from 1,205,125 metric tons in 1875 to 16,519,403 metric tons in 1897, showing an annual average increase of 50·8%. Of the total increase, 15,314,278 metric tons, 10·8% or 1,662,206 metric tons was derived from Prussia. The production of mineral salts alone, however, shows an increase from 731,586 metric tons in 1875 to 2,712,398 metric tons in 1897. Of this increase, 1,980,-811 metric tons, Prussia contributed 71·9%. The total value of mineral salts produced in the German Empire from 6,237,434 marks in 1875 to 29,345,227 marks in 1897, an increase of 23,107,793 marks; of which 17,383,975 marks, or 79·5%, is credited to Prussia.

* Including the district of Aschersleben, in which is Stassfurt, the seat of the potassium industry.

PRODUCTION OF CRUDE AND REFINED POTASSIUM SALTS FROM PRUSSIA, FOR 1898 AND 1899 INCLUDING AMOUNTS TREATED BY SALT WORKS AND CHEMICAL MANUFACTORIES.

MINERAL SALTS.

	Rock salt.		Kainite.		Other potassium salts (a)		Kieserite.		Boracite.		Total.	
	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.
Production, metric tons.....	329,959	331,943	244,241	744,657	718,958	941,055	2,061	1,793	216	171	1,795,435	2,019,629
Value per ton, marks.....	5·58	5·66	13·76	13·82	11·86	12·71	8·67	8·20	188·29	194·83		
Number of producing works	9	10	17	19	10	13	6	7	6	6		
Daily av'ge of men employed	252	267	1,692	1,913	4,596	4,970		48				

(a) Carnallite, sylvinite and Hartzsalts.

PREPARED SALTS.

	Table salt.		Potassium chloride.		Magnesium chloride.		Glauber salt.		Potassium sulphate.		Magnesium potassium sulphate.		Magnesium sulphate.	
	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.
Production, metric tons.	286,051	288,589	107,760	119,123	6,432	6,634	43,928	55,253	13,378	19,026	11,228	8,169	19,967	26,465
Value per ton, marks...	22·94	22·80	131·53	127·24	15·32	15·28	25·46	24·83	165·19	162·41	8	81 45	16·87	15·28
No. of producing works.	41	40	14	13	2	2	15	16	7	9	4	6	8	6
Daily av'e of men em'p'd	1,827	1,800	1,543	1,946			147	162	(?) 6	(?) 6				

From the above may be seen the increase in production of both mineral and manufactured salts in Prussia from 2,137,979 metric tons in 1897 to 2,435,678 metric tons in 1899, an increase of 13·9%. The mineral salts output alone rose from 1,669,771 metric tons in 1897 to 2,019,620 metric tons in 1899, an increase of 20·9%, while the statistics for manufactured salts diminished from 567,187 metric tons in 1897 to 416,058 metric tons in 1899, a decrease of 26·6%. The value of both mineral and manufactured salts increased from 42,888,523 marks in 1897 to 49,719,779 marks in 1899, an increase of 15·9%. Of this the statistics of the value of mineral salts alone were 19,204,849 marks in 1897 to 22,338,936 marks in 1899, showing an increase of 16·3%. For manufactured salts the value rose from 23,683,674 marks in 1897 to 27,370,843 marks in 1899, an increase of 15·5%. Summarizing, the total production is approximately four-fifths mineral salts and one-fifth manufactured salts, the latter having a slightly greater value. Of the total Prussian output, the Stassfurt district produced the following percentages of rock salt and potassium salts from 1890-1898:

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	%	%	%	%	%	%	%	%	%
Rock salt.....	89·02	89·00	86·39	88·75	88·37	85·65	88·97	87·97	81·50
Potassium salt....	91·03	89·13	87·12	88·45	89·49	88·98	87·71	88·19	89·34

The differences between these percentages and 100 give the share of the output of rock salt from the districts of Bonn and Breslau and of potassium salts from the district of Hanover.

The trade of potassium salts in Germany is in the hands of several organizations. The rock salt trade is managed by the committee of rock salt works at Leopoldshall, a neighboring town of Stassfurt and the seat of the Anhalt State Salt Works. The trade of the potassium salts is managed by a selling syndicate which sits in Leopoldshall and represents at present 12 works; including those in the Prussian and Anhalt States. The two new works which

TOTAL PRODUCTION, VALUE, NUMBER OF WORKS AND MEN EMPLOYED THEREIN, OF THE CRUDE AND MANUFACTURED POTASSIUM SALTS IN GERMANY, 1875-1897.

	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
MINERAL SALTS.								
1. Rock Salt :—								
Output of crude marketable products. (*a*) (Metric tons)	170,417	170,124	170,786	202,940	238,160	272,270	311,907	322,442
Value per ton. (Marks)	7·80	7·20	7·40	7·20	7·15	6·92	6·68	6·90
Number of producing works	11	10	11	10	11	12	13	12
Average number of men employed daily	588	714	719	814	1,067	785	755	767
2. Kainite:—								
Output of crude marketable products. (*a*) (Metric tons)	(*g*)	(*g*)	31,742	79,449	49,892	137,425	160,538	141,272
Value per ton. (Marks)	(*g*)	(*g*)	14·20	11·40	13·93	12·85	13·51	14·16
Number of producing works	(*g*)	(*g*)	2	2	2	3	3	2
Average number of men employed daily	(*g*)	(*g*)	(*g*)	117		470	697	816
3. Other potassium salts :—								
Output of crude marketable products. (*a*) (Metric tons)	529,359	580,897	779,975	690,765	611,781	528,423	745,353	1,060,120
Value per ton. (Marks)	8·40	8·00	7·60	8·00	9·03	9·53	9·71	9·16
Number of producing works	3	3	4	4	4	4	5	5
Average number of men employed daily	1,337	1,339	1,692	1,560	1,487	1,318	1,899	2,722
4. Bitter salts (Kieserite, Glauber salt, etc.) :—								
Output of marketable products. (Metric tons)	31	35	152	520	765	2,144	4,625	8,130
Value per ton. (Marks)	1106·20	568·60	9·40	10·00	9·97	8·19	8·26	8·89
Number of producing works	1	1	1	1	2	3	2	2
Average number of men employed daily (*c*)								
5. Boracite :—								
Output of marketable products. (Metric tons)			38	98	104	99	124	118
Value per ton. (Marks)			485·80	167	345·76	486·88	693·11	765·71
Number of producing works			2	2	3	3	3	4
Average number of men employed daily (*c*)								
SALTS OBTAINED FROM WATERY SOLUTIONS.								
1. Table salt :—								
Output of marketable products. (Metric tons)	403,498	407,760	413,592	404,379	429,051	450,187	456,958	459,499
Value per ton. (Marks) (*d*)	26·20	27·20	26·80	27·00	26·40	26·36	26·92	27·04
Number of producing works	64	64	65	66	68	66	69	70
Average number of men employed daily	3,631	3,604	3,334	3,407	3,304	3,327	3,336	3,293
2. Potassium chloride :—								
Output of marketable products. (Metric tons)	40,360	42,326	93,378	105,837	90,078	83,628	113,168	148,403
Value per ton. (Marks) (*d*)	116·60	116·20	116·00	106·20	104·08	113·41	124·50	134·62
Number of producing works	14	16	24	22	23	24	24	23
Average number of men employed daily	911	921	1,619	1,702	1,472	1,400	1,655	2,175
3. Magnesium chloride :—								
Output of marketable products. (Metric tons)	467	2,366	7,795	8,543	8,949	11,210	11,070	12,446
Value per ton. (Marks) (*d*)	41·80	38·80	37·80	28·00	22·86	20·59	16·58	17·25
Number of producing works	2	3	6	5	6	6	6	6
Average number of men employed daily	(*e*)	(*e*)	(*e*)	35	(*e*)	(*e*)	(*e*)	(*e*)
4. Alkaline sulphates :— (*a*) Glauber salt.								
Output of marketable products. (Metric tons)	13,342	7,276	13,403	10,481	22,604	46,579	49,062	48,064
Value per ton. (Marks) (*d*)	65·00	56·00	48·60	61·60	60·29	56·43	49·91	55·44
Number of producing works	7	9	9	9	16	17	19	19
Average number of men employed daily	65	6	65	93	11	173	118	124
(*b*) Potassium sulphate.								
Output of marketable products. (Metric tons)	500	216	6,219	11,028	15,749	10,602	13,280	18,810
Value per ton. (Marks) (*d*)	30·00	22·20	65·80	62·00	63·37	162·59	143·57	190·09
Number of producing works	1	3	4	6	11	9	9	10
Average number of men employed daily					80	52	95	132
(*c*) Magnesium—potassium sulphate.								
Output of marketable products. (Metric tons)	7,335	7,005	8,372	6,966	598	3,942	5,620	5,869
Value per ton. (Marks) (*d*)	57·60	29·80	53·60	19·00	13·77	37·13	42·54	61·90
Number of producing works	3	4	3	4	1	4	3	3
Average number of men employed daily (*f*)								
5. Magnesium sulphate :—								
Output of marketable products. (Metric tons)	8,038	15,023	18,221	11,452	23,347	20,493	25,908	27,052
Value per ton. (Marks) (*d*)	10·00	7·80	5·00	7·00	8·79	8·94	8·77	7·19
Number of producing works	8	10	13	9	16	14	16	14
Average number of men employed daily (*f*)								

(*a*) From these amounts of total output of crude marketable product should be deducted a certain portion that is dissolved, boiled, or given away for the manufacture of refined salts. For the actual amounts of rock salt, kainite and "other potassium salts" that appeared in the market reference should be made to the table of production furnished by the Kali-Syndicate elsewhere in this section.

(*b*) Included in "other potassium salts."

TOTAL PRODUCTION, VALUE, NUMBER OF WORKS AND MEN EMPLOYED THEREIN, OF THE CRUDE AND MANUFACTURED POTASSIUM SALTS IN GERMANY, 1875-1897.

1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
836,400	344,797	377,491	444,397	405,420	414,557	544,591	557,060	666,793	662,577	669,043	734,939	686,940	758,867	763,412
6·56	5·92	5·41	5·05	4·79	4·64	4·44	4·74	5·01	5·09	5·32	5·23	5·51	5·06	4·96
12	11	14	013	15	14	16	17	17	17	16	16	16	16	16
799	683	858	1,062	817	752	791	1,057	944	866	919	775	900	929	905
203,120	230,071	242,281	240,421	239,412	318,576	324,476	361,827	472,256	548,445	616,755	726,524	680,174	877,885	992,389
13·57	14·60	16·01	15·59	14·40	15·19	15·35	14·86	14·70	14·31	14·62	14·28	14·14	15·11	14·05
3	3	4	6	5	6	6	6	7	5	8	8	9	9	10
838	821	835	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	350	325	376	472	1,004	1,938
959,292	766,076	678,662	704,849	840,691	916,759	861,273	913,030	898,992	802,630	879,477	917,049	841,748	902,707	953,798
9·61	10·87	12·19	12·37	12·46	13·63	15·52	16·05	12·37	12·64	11·94	12·41	13·77	12·60	12·91
6	6	7	8	8	8	10	10	11	11	13	13	13	13	16
2,731	2,656	3,298	4,803	5,343	5,475	5,413	5,556	5,955	5,265	5,840	6,418	6,263	5,910	6,642
4,850	4,917	4,207	13,850	23,235	13,269	10,951	8,030	7,454	10,207	8,818	8,252	7,328	2,350	2,601
8·98	8·91	8·95	8·17	7·67	7·90	7·76	8·69	8·75	8·76	7·74	8·72	8·11	8·86	8·67
2	2	2	3	3	3	5	5	4	5	6	5	5	5	7
.....														
199	166	140	144	153	180	121	182	177	179	162	176	150	184	198
670·23	541·24	479·60	361·30	398·70	319·57	299·85	301·42	285·38	303·58	287·36	251·99	236·82	232·35	209·30
5	6	5	6	6	7	7	7	7	6	7	6	6	7	6
.....														
464,881	468,851	461,202	479,485	484,092	496,388	492,522	492,584	503,386	504,687	504,523	522,590	525,396	547,486	543,272
26·48	26·91	25·47	24·58	23·62	21·48	24·32	26·97	26·66	27·43	27·70	27·36	27·13	26·76	22·34
70	75	77	78	79	76	80	80	79	78	79	81	81	82	81
3,266	3,302	3,348	3,406	3,374	3,345	3,305	3,303	3,301	3,320	3,263	3,179	3,288	3,328	3,336
116,371	147,456	107,253	114,136	128,230	142,765	133,957	137,005	129,512	123,962	137,216	149,775	154,427	174,515	168,601
134·14	133·33	136·83	133·79	133·90	126·61	125·34	129·45	132·26	132·51	126·12	126·11	127·47	131·07	137·25
25	25	27	27	27	26	25	25	25	25	25	25	26	24	23
2,133	2,449	2,081	2,132	2,318	2,559	2,448	2,652	2,470	2,384	2,526	2,399	2,481	2,455	2,371
19,259	12,458	11,994	13,062	12,667	16,643	16,728	14,958	15,619	14,386	12,764	17,422	17,039	17,525	18,014
15·17	11·59	11·49	12·90	11·95	11·03	10·56	10·02	10·12	14·13	13·93	11·69	12·41	13·10	14·28
6	6	4	6	5	6	5	5	4	9	9	5	5	6	6
(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	(*e*)	14
47,883	57,243	60,459	63,667	53,997	52,203	69,101	68,716	79,983	74,184	77,145	71,929	71,411	71,958	68,822
51·56	47·73	44·38	32·69	28·45	25·52	24·02	25·31	25·72	27·19	25·85	23·54	22·79	24·95	25·24
21	26	32	30	29	20	29	28	29	29	28	27	26	26	24
181	192	177	209	185	175	279	336	315	213	213	200	249	267	248
16,201	12,495	18,149	17,247	25,365	33,412	29,709	31,126	37,674	26,268	27,308	23,281	19,452	19,682	13,774
167·25	172·78	162·98	155·43	158·66	148·84	165·81	158·46	160·79	163·26	164·03	164·73	165·56	165·30	164·29
8	8	11	9	12	13	12	11	12	12	12	9	11	10	10
91	123	103	67	301	77	68	42	101	49	52	47	47	8	6
13,737	25,765	27,907	29,045	24,082	11,478	16,325	11,094	10,508	11,593	14,199	14,156	9,877	4,623	7,812
50·37	52·15	53·43	53·59	51·30	79·51	79·07	77·39	75·81	78·73	79·10	77·62	78·54	74·40	76·33
5	7	7	8	7	7	9	9	8	7	5	6	8	7	4
.....														
19,591	21,009	24,601	22,994	28,974	25,110	26,978	26,376	23,126	23,879	27,520	28,628	26,028	27,161	35,072
6·51	8·86	10·28	8·06	10·08	11·34	12·99	12·10	12·30	14·07	11·51	12·41	16·47	15·88	17·74
12	13	17	17	18	16	17	17	16	17	16	16	17	17	16
.....														

(*c*) Included in "Kainite" and "other potassium salts."
(*d*) The values of salts obtained from watery solutions are given exclusive of duty.
(*e*) Included in "potassium chloride" and "potassium sulphate."
(*f*) Included in "potassium chloride."
(*g*) Included in "other potassium salts."

are being developed are under a temporary contract. The trade and the limits of the sale districts for table salt are regulated by the South German, Middle German and North German Salt Works Associations. These organizations as a whole have caused a continual growth in the industry and have extended the markets. The rock salt and table salt appears either as crude salt or powdered salt, which are used partly as table salt, partly as industrial salts and partly as a salt mixed with vermouth and iron oxide for animals. The potassium salts are used either in the crude state (ground) or are manufactured into the following chemical salts: potassium chloride, potassium sulphate, potassium-magnesium sulphate, both calcined and crystallized, calcined manure salt, 21·6% K_2O; potassium manure salt, 37% K_2O; calcined potassium manure salt, 15 to 18% K_2O; kieserite in blocks, calcined kieserite, 70% $MgSO_4$; and bromine. Although a few works in the development state outside of the Syndicate produce salts for market, yet the amounts are so small that they do not materially affect the production as given by the works of the Syndicate. Statistics showing production and utilization of potash salts for 1895-1900 as prepared by the Kali-Syndicate, are given earlier in this article.

Concentrated Salts.—The most important of these products is potassium chloride, which is used moreover as a basis for the manufacture of other potassium salts. The principal material is carnallite or, strictly speaking, the mixture of minerals which forms the deposit of carnallite (carnallite itself being present to the extent of 60%) and has an average content of 15% KCl. The extraction of potassium chloride is based on the following facts: (1) Carnallite is more soluble than the associated rock salt and kieserite. (2) It is decomposed by water which forms a solution of potassium chloride and leaves the magnesium chloride as a residue. (3) Potassium chloride is much more soluble than sodium chloride in a saturated solution of magnesium chloride. (4) Potassium chloride is more soluble when heated.

It is thus easily understood that by treating the mineral with a hot saturated solution of magnesium chloride, the potassium chloride will be dissolved and subsequently precipitated from the solution by cooling. In practice the operation is quite complicated. The principal steps, however, are as follows: The mineral, crushed in its passage from the mine, is thrown into a boiling, saturated solution of magnesium chloride contained in large sheet-iron vats. The mixture is thoroughly agitated by steam jets and brought to a given degree of concentration, 32°B. It is then drawn out through a screen set in the bottom of the boiler which removes the coarse impurities. The solution is further clarified by resting a short time in the metal vats and is then led into the crystallizing vats and cooled. After three or four days the crystals of potassium chloride are deposited, a product that is impure and contains about 60% KCl. The mother liquors, still rich in potassium chloride, are strained and concentrated by boiling. During the evaporation sodium chloride is deposited and the supernatant liquor is cooled in another set of crystallizing vats forming artificial carnallite, KCl, $MgCl_2$, $6H_2O$, almost the entire amount of potassium being thus obtained. This new product is treated as a mineral, but its purity allows of an extraction by a single crystallization of all the potassium chloride contained. These

crystals, as well as those of the first crystallization, are contaminated by sodium and magnesium chlorides which are removed therefrom by a series of washings with water. In this manner after drying a potassium chloride is obtained of from 80 to 99% KCl content. The wash waters charged with magnesium chloride are used for the dissolution of the mineral. Several modifications of this method give a richer product in a shorter time and the manufacturers at Stassfurt produce several qualities of the salt, graded from 70 to 98% KCl. The potassium chloride for fertilizing purposes is sold on an 80% basis of pure KCl (55·5% K), its price being determined from its analysis.

The potassium chloride salt serves as a basis for the manufacture of other potassium salts. It is utilized in the manufacture of chemical products, in the preparation of saltpeter by the reaction on sodium nitrate, for potassium chlorate and bichromate and for alum. The 90 to 98% KCl salts are best utilized for the manufacture of potassium carbonate. The carnallite furnishes also the principal material for other products utilized in the industries and in agriculture. In this connection must be named first the kieserite or magnesium sulphate, which constitutes the mud residues of the different treatments of carnallite. These mud residues when calcined form the so-called "calcined kieserite" used as a fertilizer; or they are ground and formed in molds giving the "block kieserite." Among the by-products of the manufacture of potassium chloride is also obtained magnesium chloride, which is used considerably in the English spinning factories;* sodium sulphate, which is particularly valued in the manufacture of glass on account of its purity; bromine and iron bromide, which are obtained from the concentrated waters collected at the end of the operations. Finally various works prepare as well calcined magnesia, magnesium hydrate, chloride of lime and the double salt, potassium-magnesium carbonate. Kainite is utilized for the manufacture of potassium-magnesium sulphate so largely used as a fertilizer. The product is made either in the calcined or crystallized state. When in the latter form it contains 42% K_2SO_4 (21·6% K) and is used only for the manufacture of alum; the calcined variety is somewhat richer, 48% K_2SO_4 (25·9% K). The manufacture of potassium sulphate is not so extensive as that of potassium chloride. Numerous processes are used, one of the principal ones being as follows: The kainite is dissolved and the potassium-magnesium sulphate is recovered from the heated solution by cooling, this material is then heated with potassium chloride which reacts upon it and forms potassium sulphate and magnesium chloride. The potassium sulphate product varies in richness from 90 to 96% K_2SO_4 (approximately 40 to 48% K) and is sold mainly for agricultural purposes; a considerable amount however, is manufactured into potassium carbonate by the Leblanc process. The Stassfurt works utilize also the various by-products from the manufacture of potassium chloride: the insoluble residue from the washings; the deposits in the clarifying tanks, boilers, etc., and produce therefrom, principally magnesium and sodium salts, although they may contain from 20 to 30% K as KCl. These residues are ground, dried, calcined and enriched by the addition of crude sylvinite

* Stiffening material (starch) is spread over the threads of the warp and woof to give them rigidity, but as it dries very rapidly, a small quantity of magnesium chloride is added to keep it moist.

or even potassium chloride. They are sold under various names for fertilizing purposes.

The labor employed in mining the crude salts in Germany was in 1875 1,925 men and in 1897 9,485 men. Of these Prussia's share was 784 men in 1875 and 5,756 men in 1897. In the manufacture of salts from aqueous solutions the number of men employed in all Germany in 1875 was 3,696 and in 1897, 3,975. Of these Prussia employed 2,005 men in 1875 and 3,653 men in 1897. For Prussia only, the number of men employed in mining crude salts was 6,542 in 1898 and 7,198 men in 1899, while in the manufacture of salts from aqueous solutions the numbers were 3,523 men in 1898 and 3,908 men in 1899.

LABOR STATISTICS FOR THE GERMAN EMPIRE.

	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.b
Underground Miners:													
Number of workmen	2,253	2,430	2,478	2,344	2,295	1,912	1,854	2,000	1,882	1,718	1,935	2,131	2,155
Number of shifts worked per man	301	291	291	294	294	303	299	292	281	302	301	302	300
Wage earned per shift (in marks) (a)	3·08	3·11	3·26	3·48	3·63	3·81	3·69	3·65	3·56	3·65	3·81	3·81	3·85
Other Underground Labor:													
Number of workmen	203	210	200	185	170	198	658	769	704	636	736	821	855
Number of shifts worked per man	315	321	316	307	308	306	302	297	289	303	305	306	302
Wage earned per shift (in marks) (a)	3·38	3·47	3·42	3·47	3·59	3·47	3·30	3·19	3·26	3·34	3·40	3·43	3·58
Workmen Above Ground:													
Number of workmen	886	950	1,011	1,032	1,097	1,091	1,193	1,129	1,133	1,163	1,233	1,338	1,418
Number of shifts worked per man	320	323	324	315	312	312	305	306	298	305	306	307	307
Wage earned per shift (in marks) (a)	2·92	3·02	3·06	3·24	3·35	3·35	3·33	3·38	3·38	3·43	3·49	3·50	3·50
Boys:													
Number of boys	100	98	79	68	90	88	86	77	60	57	81	101	105
Number of shifts worked per boy	308	301	299	311	302	298	298	296	287	300	300	301	298
Wage earned per shift (in marks) (a)	1·17	1·09	1·21	1·26	1·25	1·32	1·24	1·21	1·25	1·17	1·20	1·21	1·28

(a) After subtracting all fees. (b) For Prussia only.

The labor statistics regarding the officials of the Prussian salt mines during 1890-1899 are as follows:

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Number of officials	118	121	124	130	136	131	128	141	157	163
Salary for 1 official (in marks)	1,759	1,816	1,796	1,893	1,812	1,799	1,828	1,831	1,884	1,933

From the above table it may be seen that the number of officials increased from 118 in 1890 to 163 in 1899, or 38·1%. The average salary during the same time rose from 1,759 marks in 1890 to 1,932 marks in 1899, corresponding to 9·8%. In 1899, with 4,533 hands in the Prussian salt mines, there was an average of 28 men to one official.

The averages of the miners' work have not been published for Germany or Prussia alone, but the table following was made up from the largest Prussian State mine in Stassfurt and these statistics, while they do not hold good for all circumstances of the same items in salt mining and cannot always be taken as a standard, yet they may be regarded as a fair representation of work that is carried out in salt mines.

	Rock salt.					Potassium salts.				
	1875.	1880.	1890.	1895.	1897.	1875.	1880.	1890.	1895.	1897.
Average output of one miner proper per shift of 8 hours (metric tons).. {Strike.....		3·45	7·35	17·29	19·927	5·15	4·50	8·57	21·24	23·99
{Overhead stope	27·35	15·10	27·58			29·85	28·85	28·50		
Output of 1 underground workman per shift of 8 hours (metric tons).....	3·10	2·90	4·20	3·50	2·60	2·80	2·25	2·47	3·26	3·06
Wages per shift of 8 hours (marks)... {1 miner proper	3·88	3·51	4·38	4·73	4·95	3·88	3·61	4·21	4·65	4·85
{1 trammer.....	2·75	2·61	3·47	4·33	4·29	3·00	2·48	3·36	4·28	4·16
{Altogether.....	2·80	2·94	3·71	3·84	3·88	2·80	2·93	3·60	3·76	3·82

Statistics for the average work in the salt works (Salinen) and chemical manufactories have not been published as yet. The figures compiled from the largest salt works of the Prussian State, at Schonebech, from 1875 to 1882, are given in the following table:

AVERAGE ANNUAL PRODUCTION PER MAN. (METRIC TONS.)

1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
142·7	133·15	350·70	332·40	350·15	365·17	371·52	386·50

NUMBER OF MEN EMPLOYED AT THE MINES OF THE KALI-SYNDICATE.

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Rock salt.....	6,766	1,355	1,985	788	1,333	1,092	1,121	1,251	1,530
Potassium salts....		6,819	6,074	7,624	10,800	9,700	10,683	10,909	12,358
Total.....	6,766	8,174	8,059	8,412	12,133	10,792	11,804	12,160	13,888

In the Prussian salt mining industry during 1899 three men were fatally wounded underground, and two on the surface, making a total of five men which, with a total force of 4,533 men employed during 1899, gives a percentage of 1·1 fatality per 1,000.

Geology and Technology of the Potassium Salts Industry of Germany.

By Friedrich Klockmann.

Within the past few years the mining of potassium salts and its allied chemical industries has attained an extraordinary development which places them on a plane with Germany's great industries of coal and iron. In fact, Germany now rules the world's potassium salts markets, and it is from her resources that every country supplies its needs in these products so necessary to the maintenance of modern methods of agriculture. The present importance as well as the future prosperity of this industry is based on the following conditions: (1) Wide use of fertilizers, in which potassium salts are indispensable constituents; (2) limitation of potassium salt deposits so far as known to Germany; (3) great extent and richness of the beds. With these facts before us it is easy to comprehend how the exploitation of these treasures has led to improved methods in agriculture, developed many large technical industries, and at the same time has commanded the attention of the capitalist, the speculator, the legislator and the politician.

The history of mining for potassium salts in Germany is brief, but not without interest. About 1830 a bed of rock salt was found by drilling in the vicinity of Erfurt in the Thuringian basin, a discovery which attracted cou-

siderable notice, and led to explorations in other districts, particularly that of Stassfurt, north of the Harz, where the manufacture of salt from brines had been carried on for centuries. In 1843 a prospect started four years previously encountered a salt bed at a depth of 256 m., which, upon examination, proved to be composed of a mixture of magnesium and potassium salts. The result was looked upon as unfavorable, but operations were continued, and at greater depth a bed of the prized sodium chloride was found of so great an extent that, although the drilling was continued down to 581 m., the base of the deposit was not reached. Nothing further was done until the Prussian Government decided to undertake the exploitation of the beds, and began to sink shafts in 1852. In order to get at the rock salt, the beds of potassium and magnesium salts first had to be cleared away, from which fact the common name "Abraum" (remove or waste) salts is derived. After repeated attempts the utilization of this material was successfully accomplished, and through the efforts of A. Frank the first large manufactories were established. Immediately further explorations were commenced in the vicinity of Stassfurt. The Government of Anhalt also undertook to develop the industry at Leopoldshall, in the immediate neighborhood of Stassfurt, while the mines at Loederburg, Westeregeln, which were subsequently taken over by the Neu Stassfurt and Douglashall works, were developed by private enterprise. To this list were added from time to time other new companies, notably Ludwig II., Schmidtmannshall, and the German Solvay Works, while beyond the limits of the Stassfurt district were the Vienenburg mines at Goslar, the Anderbeck mines near Halberstadt, those of Luebtheen in Mecklenburg, and of Thiede in Brunswick. These were the first undertakings which established the credit of the German potassium salts industry, and to whose success was due the feverish activity that prevailed for some years in this field. In 1889 further prospecting was commenced between Goslar and Hildesheim by the Goslarer Tiefbohrgesellschaft, and in the Allerthal, north of Helmstedt by a company afterward formed into the Gewerkschaft Burbach. The success attending these undertakings aroused widespread interest, and, favored by an active mining market as well as outside capital, many new companies were formed whose field of operations extended over a great part of north and middle Germany, more especially the Province of Hanover, and the Thuringian States. Most of these companies failed to locate workable deposits and went into liquidation. Of the survivors, some still continued boring, while others are now sinking shafts and getting ready to exploit the deposits which they have proved by drilling. At the present time capitalists are much more reserved toward these enterprises, and very few new ventures are heard of. The fear which prevailed at one time that the new discoveries would bring about an overproduction, and a consequent decline in prices, and possibly ruin of the older works, has proved groundless. So far the increase in output from this source has only been normal. These discoveries, however, have assured a long life to the industry.

GEOLOGICAL RELATIONS.—The potash deposits are always found associated with rock salt. Beds of the latter occur in all parts of the world, and in various geological formations, but potassium salts and the accompanying magnesium

salts have so far been discovered only in the Zechstein formation (Dyas) of Germany. The beds occur in the upper part of the Zechstein, and are overlaid by Triassic sandstone. The Zechstein, and especially its upper salt-bearing member, extends over a large territory in northern and middle Germany. The strata have been found as far east as Inowrazlaw, on the Russian-Germany boundaries, to the west as far as Wesel on the Rhine, near the frontier of Holland, while from north to south they extend from Holstein and Helgoland to the south of the river Main. The rocks are seldom found outcropping, and it is to this fact and to the covering of later Buntsandstein (lower Trias) that the

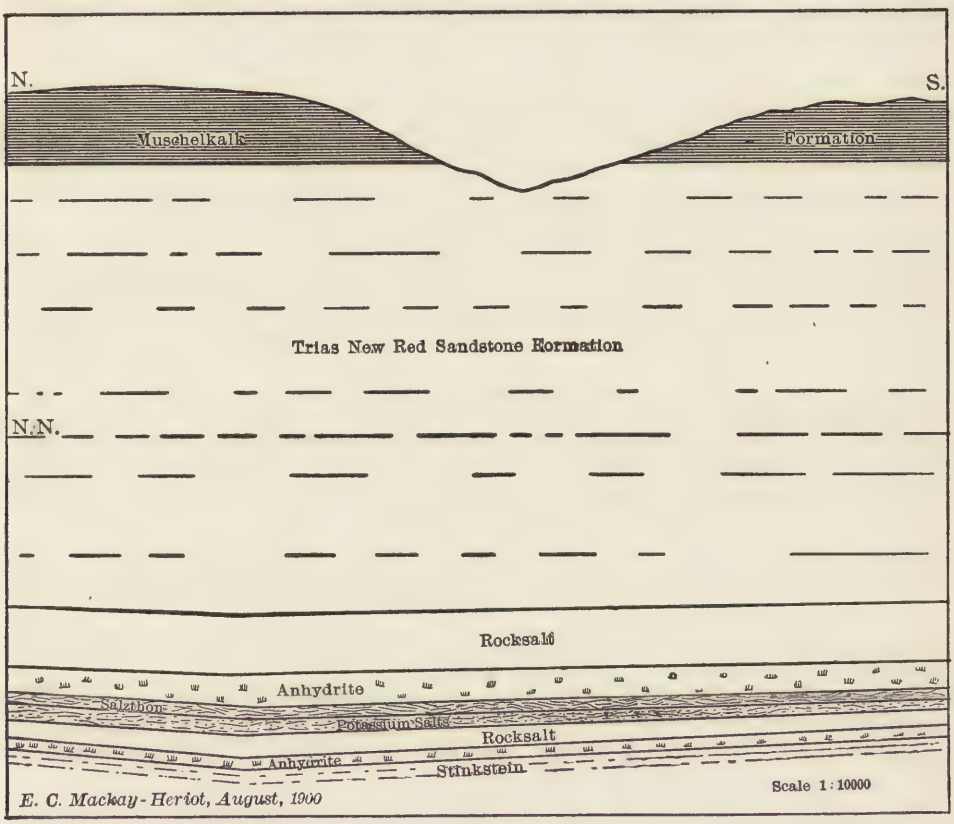


FIG. 1.—SALT FORMATION OF THE STASSFURT TYPE IN THE EICHSFELD BASIN.

preservation of these easily soluble salts is due. In the mountainous parts of Germany the strata give way to large areas of older rocks and around the edges of such areas the Zechstein outcrops in the form of limestone, anhydrite, gypsum and clay, which are more resistant to weathering influences. The borders of the Harz, and of the Thuringian forest, and the western side of the Westphalian schistose region are thus formed by the Zechstein. Small isolated areas, where this rock rises to the surface, are also found, and many of these are known, for instance at Sperenberg, in the vicinity of Berlin; also at Stade, Lueneburg and Segeberg, in the lower Elbe district.

From the geological relations it is evident that those regions are more likely to contain deposits of potassium salts whose surfaces are covered by the Buntsandstein, as this rock most frequently directly overlies the Zechstein deposits, and it is here that the latter may be looked for at the least depths. This principle has been made use of in exploring the region west of the Rhine and north of the Main, and it has been found that the Zechstein is nearly always accompanied by rock salt, but only in certain cases by the potassium and magnesium salts. The deposits of rock salt attain a thickness of many hundreds of meters and some even a thousand. They underlie a greater part of the north German lowlands and the elevated or hilly region of middle Germany. It is a matter of regret that these immense deposits have as yet found no adequate utilization. The territory in which the potassium deposits are most frequently found is that surrounding the Harz, the Provinces of Hanover and Saxony, and also Anhalt and Brunswick. Explorations have been carried out also with more or less favorable results in the Thuringian forest region, near Osnabrueck, and in the Allerthal between Magdeburg and Celle. An explanation of the fact that the beds of potassium salts are not always coextensive with those of rock salt will be found in another part of this article.

The first information regarding the structure and relation of the salt beds was derived from the mines in the neighborhood of Stassfurt. The geological section as shown here also in a general way corresponds to that exhibited in all the mines of the Stassfurt-Westeregeln region. (See Fig. 1.) It may be termed the normal section. Essentially it consists of extensive rock salt beds, which overlie large deposits of anhydrite, and in turn are overlaid by argillaceous strata (Salzthon), anhydrite and the Buntsandstein. The rock salt beds which are classed by geologists as belonging to the upper Zechstein are divided by intercolated strata of other minerals into a series of lesser beds which are commonly called "regions." The rock salt that immediately overlies the anhydrite is first divided into strata of from 8 to 9 cm. thickness by thin bands of anhydrite, which give the name "anhydrite region" to this part of the deposit. Over this follows rock salt with stringers of polyhalite (the polyhalite region); then follows the kieserite region, and, at the end, the carnallite region. This latter is the most important. It consists of a mass of rock salt with variable amounts of kieserite and carnallite, and has a total thickness of from 1 to 40 m. It is characterized by a considerable uniformity, and is of large extent, so that notwithstanding its variable chemical composition it is to be considered the basis of the mining and chemical industry. In many places the carnallite is replaced by other potassium salts, as kainite, schoenite, sylvinite and hartsalz. These salts, however, appear only where the strata have been bent or folded. They occupy the highest parts of the saddles, so that it would appear they are not original deposits, but have been formed by secondary crystallization out of the carnallite. This is further attested by the fact that carnallite when dissolved in water suffers decomposition, and can only be crystallized out of a solution containing at least 25% $MgCl_2$. In the Stassfurt section the region of carnallite and its decomposition products is overlaid by the so-called *salzthon,* which acts as a protective mantle. This stratum has a varying

thickness seldom exceeding 10 m., is gray or reddish in color, and consists of finely divided clay impregnated with anhydrite and magnesium carbonate. Over this lies here a bed of anhydrite, the highest member of the Zechstein formation, which reaches a thickness of 100 m. It has also served to protect the salt beds from being carried away in solution. In many places the anhydrite stratum contains extensive rock salt deposits that are usually characterized by a coarse crystalline texture and remarkable purity. These deposits are commonly called the "later rock salt," in contrast to the older formation which is associated with potassium salts. They have been regarded as of secondary origin, being derived from the solution and redeposition of the older salt beds. The anhydrite in turn is overlaid by the Buntsandstein, which has a thickness of 300 to 500 m.

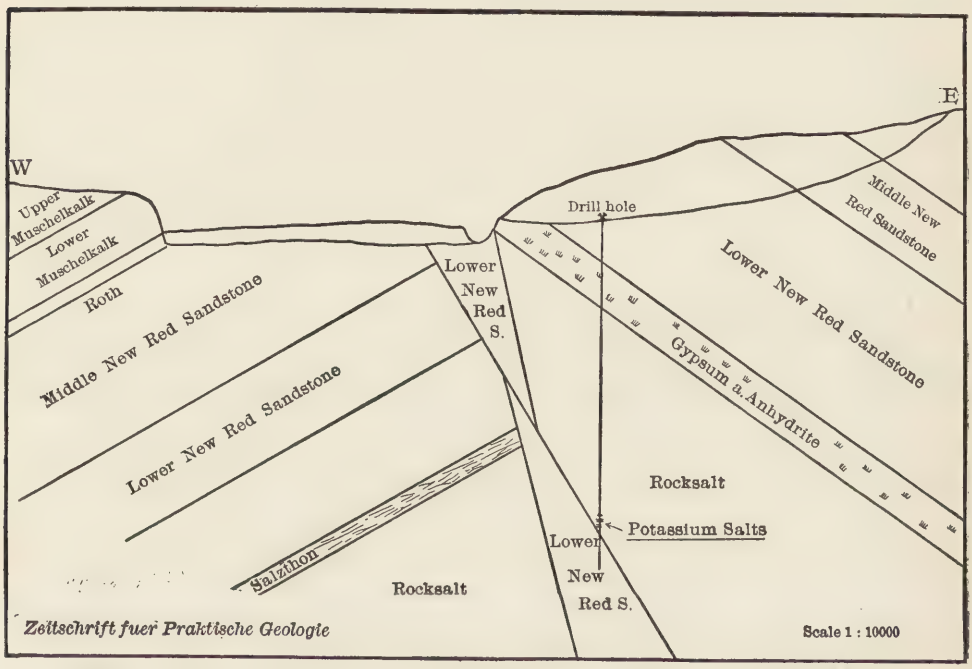


FIG. 2.—SALT FORMATION OF THE HANOVER TYPE NEAR HANOVER.

In contrast with this Stassfurt or normal section almost all of the drilling tests made in the last decade, notably in Hanover, Brunswick and Thuringia (see Fig. 2), have shown the division of the rock salt into an older and younger niveau and the sub-classification of the former into regions to be untenable. On the other hand the salt bearing upper Zechstein is a complex of rock salt and anhydrite in alternating strata of varying thickness, while the potassium salts changes from carnallite to sylvinite in character, and may appear in the rock salt, or as impregnations in the anhydrite. But it seems very likely that in general these alternating beds of rock salt and anhydrite correspond with the younger salt-horizon of the Stassfurt mines. Drill holes, even when located at very small distances apart, also have given widely varying

results in regard to the number and thickness of the potassium salt strata. This naturally leads to the conclusion that the beds are lens-shaped, a fact which makes it extremely difficulty or even impossible to judge the value of new deposits. It has also been found that the potassium salt lenses are not sharply defined toward the rock salt, but grade into the latter through a gradual loss of potash. The difference between the character of the Stassfurt and the Hanover-Thuringian sections at first was not clearly recognized, which consequently led to much confusion, useless drilling and wrong opinions as to the value of new deposits.

The strata of the salt formation usually exhibit evidence of disturbance, being thrust up at various angles or thrown into folds. These structural characteristics have been made use of extensively by the prospector in searching for new deposits, it being assumed that the most favorable ground was along the strike or on the adjacent anticlinal of a fold of known beds. It may be stated, however, that too much reliance has been placed upon these tectonic peculiarities. Many times the beds have remained undisturbed, but then are usually barren of kainite. It has been found not uncommonly in drilling through strata inclined at high angles that both the foot and hanging walls are Buntsandstein, a phenomenon that is to be explained by faulting along the strike or by thrusting. The peculiar markings and folds exhibited by the varicolored salts, however, are not to be ascribed to the effects of tectonic processes, but to the pressure exerted during the crystallization of the salts themselves.

As to the origin of these salt beds, it is extremely difficult to advance any theory that is satisfactory in all particulars. In general it may be assumed the anhydrite, rock salt and the potassium and magnesium salts represent the crystallization products of an inland sea to which the waters of the ocean had access through a shallow channel that did not allow the passage of the heavier, partially evaporated solution. This theory explains both the enormous extent of the deposits and their arrangement in a series of layers corresponding to their relative solubilities. The potassium and magnesium salts in the upper region represent the most soluble, and the last product to form from the evaporation of the sea, while the least soluble, the anhydrite, is found at the base with rock salt overlying. That the potassium salts are not distributed over the entire area is due in the first place to the fact that the sea water contained relatively only small quantities of this element, and further, to the solubility of the minerals which would render them more liable to removal by underground waters than the other salts. Many instances can be cited where the deposits have thus been removed.

Mineralogy of the Salts.—Omitting consideration of the gypsum, anhydrite and rock salt, which do not interest us in this connection, the minerals found in the deposits may be divided according to their chemical composition, and utilization into two groups: potassium salts and magnesium salts. A few minerals of lesser importance do not come under either head. Also, according to their origin, they may be classified into primary and secondary salts, the former being those which crystallized directly from the sea water, while the latter includes such as owe their origin to the solution and deprecipitation of the

older deposits. This classification cannot be sharply drawn, as such minerals as carnallite and sylvin occur both as primary and secondary products. The primary salts are often colored reddish through the inclusions of thin blades of hematite; the secondary are lighter in color and much purer.

Carnallite, KCl, $MgCl_2$, $6H_2O$, is the most important of the potassium salts in the Stassfurt district, both as regards quantity and uniformity of distribution. It is the mineral which forms the basis of the chemical industry. Chemically pure, it contains 26·8% KCl or 14% K, 34·2% $MgCl_2$, 36% H_2O, but in nature it is almost always associated with more or less rock salt, kieserite and other minerals through which the percentage of KCl is reduced to less than half the theoretical amount. It is also the most important of the primary minerals, but now and then occurs as secondary, and is then very pure. It is usually colored reddish by the presence of small scales of hematite, while yellow and pure white varieties are very seldom found, and then only in the secondary beds. It is easily soluble in water, but suffers decomposition, a characteristic which is made use of in chemical manufacture.

Sylvin, KCl, is richer in potassium than carnallite, containing 52·46% K. In the Stassfurt mines it is of secondary origin, being derived from the decomposition of carnallite, while it is a primary constituent of the Hanover and Brunswick deposits. When mixed with considerable amounts of rock salt it is called *sylvinite.* Its color is white, yellow or red, the first variety being the most common.

Kainite, KCl, $MgSO_4$, $3H_2O$, formed by the decomposition of carnallite, is the most important of the secondary minerals, and is widely distributed in the mines of the Stassfurt district. When not too impure it can be ground and used directly for agricultural purposes. It is usually, however, mixed with considerable amounts of rock salt, and is then called hartsalz, a name which is commonly applied, also, to potassium-magnesium salts containing rock salt, but no magnesium chloride. These require chemical treatment before they are commercially valuable.

Schoenite, or *pikromerite,* K_2SO_4, $MgSO_4$, $6H_2O$, is a secondary product of carnallite, less widely distributed than kainite.

Polyhalite, K_2SO_4, $MgSO_4$, $2CaSO_4$, $2H_2O$, is interesting through its occurrence in the form of bands within the so-called polyhalite region. It is of no commercial importance.

Kieserite, $MgSO_4$, H_2O, is the most important and extensively distributed of the magnesia salts. It is a shining, yellow mineral, easily decomposed by water, thereby forming bitter salts or Epsomite, $MgSO_4$, $7H_2O$.

Among the other potassium and magnesium salts of no technical significance may be mentioned: Glaserite, K_2SO_4; krugite, K_2SO_4, $MgSO_4$, $4CaSO_4$, $2H_2O$; bishofite, $MgCl_2$, $6H_2O$; tachydrite, $2MgCl_2$, $CaCl_2$. $12H_2O$; astrakanite (bloedite), Na_2SO_4, $MgSO_4$, $4H_2O$, and douglasite, 2KCl, $FeCl_2$, $2H_2O$. The latter mineral is remarkable for the fact that it readily decomposes with the evolution of hydrogen in large quantities.

Of other salts containing no potassium but of scientific or technical interest, the following are deserving of mention: boracite, $Mg_7B_{16}O_{30}$, Cl_2, which occurs

in the form of nodules within the carnallite region; pinnoite, MgB_2O_4, $3H_2O$; glauberite, $Na_2SO_4CaSO_4$; sulphur, pyrite, and hydrogen sulphide, H_2S. The last mentioned is often a source of great danger to miners.

It is extremely difficult and often impossible to distinguish the different minerals with the mere eye, and for this purpose, as well as to arrive at the value of the different salts, it is absolutely necessary that chemical analysis go hand in hand with the mining.

Development and Exploitation of the Mines.—The various enterprises may be grouped under three heads, according to their stage of progress: (1) Productive mines; (2) mines under development; (3) companies engaged in drilling.

(1) Since the year 1852, in which the Prussian Government sank the first shafts "Manteuffel" and "Von der Heydt," near Stassfurt, a large number of mining companies have reached the productive stage. These, as well as the chemical works, in order to protect their interests, united and formed a syndicate with which all the new producers from time to time have become connected. The present members of the syndicate, with the year in which each began operation, are as follows: Der koeniglich preussiche Fiscus of Stassfurt, 1852; Der herzoglich anhaltische Fiscus, of Leopoldshall, 1857; Consolidirte Alkaliwerke, of Westeregeln, 1871; Salzbergwerk Neustassfurt, of Stassfurt, 1877; Gewerkschaft Ludwig II., of Stassfurt, 1881; Kaliwerke Aschersleben, of Aschersleben, 1882; Gewerkschaft Hercynia, of Vienenburg, 1884; Deutsche Solvay-Werke, Actiengesellschaft, of Bernburg, 1885; Actiengesellschaft Thiederhall, of Thiede, 1885; Gewerkschaft Wilhelmshall, of Anderbeck, 1887; Gewerkschaft Glueckauf, of Sondershausen, 1893; Gewerkschaft Hedwigsburg, of Wendessen, 1895; Gewerkschaft Burbach, of Beendorf, 1897. With the exception of the Glueckauf, which lies upon the south side of the Harz, all the other mines are situated in the northern part of the Harz district. The first six mentioned and the Solvay works are within the Stassfurt basin, the Hercynia is in the vicinity of Goslar; while the Wilhelmshall is not far from Halberstadt in a continuation of the Stassfurt basin westward that includes also the mines of Thiederhall and Hedwigsburg in Brunswick. The Burbach mines are on the northern border of the Stassfurt basin, not far from Helmstedt. The relative importance of the different mines may be seen from the table which appears early in this section, giving the production of each mine in terms of the total output.

All the mines are supplied with modern machinery and compare favorably in this respect with any other class of mines in Germany. In fact, they represent the highest development of German mining technique as regards machinery, ventilation, hygiene and costs of production. Most of the mines have more than one shaft. Electricity is used in transportation, lighting and drilling. The methods of working the mines vary according to the physical qualities of the minerals and the dip of the beds; usually the panel or stoping system is adopted. Gobbing is practiced in all mines, the material for which, rock salt, is broken in mills built specially for this purpose. Drainage is unnecessary, but when water appears it may cause a closing down of the mine, as

has lately happened with the Leopoldshall. Wages are high, the workmen well fed and contented. In addition to the chemical works which are directly connected with the mines, there are extensive mills for breaking and pulverizing the minerals used for agricultural purposes.

(2) The mines under development occupy a middle position between the first and third group and comprise those in which the drill tests were sufficiently favorable to warrant further development. In the first part of the present decade, influenced by the feverish excitement that prevailed at this time, the expensive operation of sinking shafts was often undertaken with only the scanty knowledge regarding the deposits that could be gained from a single drill hole. It was soon learned that this was a very expensive manner of procedure, as the results actually obtained did not correspond with those shown in the drill. This common experience also brought about a great decline in the market prices of the stocks of these companies.

Shaft sinking offers no special difficulties so long as continued in the firm Buntsandstein. A simple lining of masonry suffices, the material for which is often taken from the surrounding fields. After the rock salt is reached, a cross-cut is run to the ore deposit. Very frequently water is encountered and then tubing must be used. The presence of quicksand, fissured or diluvial sand, necessitates the adoption of freezing or other particular methods suited to the case, but so far the German engineers have successfully met all difficulties. An instance of remarkable perseverance under adverse conditions is that of the "Mecklenburgische Kalisalzwerke" of Jessenitz near Luebtheen, which has just succeeded in reaching the rock salt after 15 years of continuous labor and great expense. The costs of shaft sinking vary greatly and cannot be previously estimated, as they depend not only upon the depth but also on other circumstances, particularly the difficulties that may ensue from water. Ordinarily the expense runs from 1,000,000 to 2,000,000 marks or somewhat more. The shafts have a circular cross-section with a diameter of about 5 m.

(3) As already stated, there has been a great falling off during the past few years in the number of exploration companies. At one time the discovery of the outcrop of Buntsandstein or a salt spring was sufficient excuse for putting down a test hole. Under the excitement of the time capital was easily induced to take hold of such enterprises, many of which were organized rather for the purpose of speculation than from hopes of profitable exploitation.

The laws in regard to deep drilling are not uniform in the different German States. Some of the north and middle German States, notably Anhalt, Mecklenburg, Brunswick and Lippe, recognizing the great agricultural and financial value of the deposits, immediately declared the rights of exploration a State monopoly, which they afterward transferred under large guarantees to a single or limited number of individuals. In Prussia the conditions were different for the Provinces of Saxony and Hanover. In Saxony the right of prospecting was free; the mining concession belonged to the first discoverer of the deposits without regard to the owner of the soil surface. Favored by such liberal laws a great number of exploration companies soon sprang up, but their existence was a short one, as the older productive mines of this province as well as Prussia

and Anhalt, foreseeing future competition, founded a strong exploration company, which soon drove the newer rivals from the field. Important discoveries later on in Hanover again created great activity among the independent companies and they have even ventured once more into the bounds of Saxony.

According to the laws of Hanover the mining rights belong to the owner of the soil surface, from whom a permit must be acquired before any prospecting can be done. At first this permit could be had cheaply, but now the owner demands a good price without regard to the chances of ultimate success and also stipulates that he shall receive a certain sum for each centner of potassium and rock salt that may be mined. The entire province has been canvassed for the purpose of securing these rights by speculators who, in turn, disposed of them to others or made them the basis of stock companies. The latter issue usually 1,000 shares at a par value of 100 to 1,000 marks to defray the costs of mining rights and drilling. These shares being subjected to violent fluctuations have been the favorite objects of the speculators. More than 150 companies of this character have been formed since 1890. Many of them drilled several holes, while others were liquidated without accomplishing anything. When it is stated that only a few of this number have attained valuable results, one can gain an idea of the enormous sums of money that have been squandered in such enterprises. In a general way the only parties who have largely profited by this industry are the speculators, the banks and the drilling companies. The latter exacted good prices as well as favorable terms in other respects. As much as 150 marks per meter was paid for putting down a drill hole, the actual cost of which would scarcely amount to 50 marks. One valuable result, however, has ensued; the development to a high degree of the technique of drilling. Within the last decade probably 150 drill holes have encountered salt beds. The depth of the holes varies from 200 to 1,400 m. (Salzdetfurth) and the whole amount of drilling may be placed at 150,000 m., being rather above than below that figure.

Drilling is mostly by the diamond core drill, the steel bit being used only in sinking through the loose surface material. When salt beds are reached a concentrated solution of magnesium chloride is used instead of water to wash away the fine material broken up by the drill. The drill companies usually guarantee a core at least 80% of the entire drill depth.

As soon as the presence of salts is assured to the satisfaction of the mining officials the company can obtain the rights to a certain area of surface, amounting in Prussia to 2,189,000 sq. m. This is insufficient for the needs of an active mine and the companies aim to get new concessions by drilling in adjacent areas.

Chemical Preparation and Utilization.—The crude products of which mention has already been made, are partly consumed directly or after pulverization, while the remainder undergo chemical manufacture. Chemical works have been established by the different mining companies and there are also a large number of independent concerns that derive their materials from the mines under a strict compact as to the manufacture and sale of the products. The names of the independent concerns are here given in the order of their estab-

lishment: Chemische Fabrik Kalk, Leopoldshall, 1861; Chemische Fabrik Fr. Mueller, Leopoldshall, 1862; Chemische Fabrik Harburg-Stassfurt vorm. Thoerl & Heidtmann, 1870; Stassfurter chemische Fabrik vormals Vorster & Gruenberg, 1871; Vereinigte chemische Fabriken, Leopoldshall, 1872; Chemische Fabrik Concordia, Leopoldshall, 1872; Chemische Fabrik Maigatter, Green & Co., Leopoldshall, 1872; and Chemische Fabrik Beit & Co., Stassfurt, 1876 and 1881.

We will now briefly discuss the preparation and utilization of the different mineral products.

Rock Salt, NaCl.—The output of rock salt, at least so far as concerns its use as food, is not at all proportionate to the extent of the deposits. This is due to the common preference of brine salt for this purpose and to the fact that the latter is purer. The consumption of salt per capita is also quite stable so that as yet there has been no increase in demand which the manufacturers of brine salt could not readily supply. While the difference in price is considerable—the rock salt selling for 4·5 marks per metric ton; brine salt 27 marks per metric ton—this is no important factor, as all salt used for food purposes pays a tax of 120 marks per ton. A certain amount of rock salt is marketed as cattle salt, but a large proportion of it is used in the technical industries, *viz.:* for the manufacture of soda, caustic soda, and hydrochloric acid and in dye works. The German consumption of rock salt for food purposes in 1897 was 419,999 tons, or 7·8 kg. per capita. The total consumption of salt in Germany in 1878 was 606,346 tons, or 13·6 kg. per capita; in 1888, 762,681 tons, or 15·8 kg. per capita; and in 1897, 1,027,373 tons, or 19 kg. per capita. In the manufacture of soda from salt both the Leblanc and the Solvay processes are used, but there are no accurate data available as to the relative importance of the two. A table prepared for the world's exposition at Paris gives the following figures for the production of soda in the different countries:

Countries.	1884.		1894.	
	Leblanc Soda. Metric tons.	Solvay Soda. Metric tons.	Leblanc Soda. Metric tons.	Solvay Soda. Metric tons.
England	380,000	52,000	340,000	181,000
Germany	56,500	44,000	40,000	210,000
France	70,000	57,000	20,000	150,000
United States	*Nil.*	1,100	20,000	80,000
Austria-Hungary	39,000	1,000	20,000	75,000
Russia	*Nil.*	*Nil.*	10,000	50,000
Belgium	*Nil.*	8,000	6,000	30,000

The present production of soda in Germany may be estimated at 250,000 to 300,000 metric tons.

A large part of the sodium sulphate recovered as a by-product in the Leblanc process is used in the glass industry as a substitute for the more expensive soda. Rock salt also finds application in the manufacture of caustic soda. The method used has not changed essentially in the past few years, being the causticization of crude soda lye. Large amounts of this product are used in the German color industry, while a certain proportion, valued at about 1,000,000 marks, is exported.

Another product from rock salt is hydrochloric acid. No improvements have been made lately in its manufacture. An idea as to the importance of this

industry may be gained from the statement that the exports in 1898 were 13,393 tons, valued at 603,000 marks. Enormous quantities of acid are consumed at home. A certain part of the acid is used in the manufacture of chlorine and chloride of lime, but the amount thus utilized is steadily declining, owing to the introduction of the electrolytic chlorine process.

The central point of the whole German salt industry lies in the utilization of the crude and manufactured potassium salts. The principal product is potassium chloride, which serves as a basis for the manufacture of most of the other potassium salts. The relation between the output of potassium chloride and the other crude products may be seen from the statistics published elsewhere in this section. Of the total output of crude potassium salts about three-fourths are used in agriculture and one-fourth in the chemical industry. This relation, however, does not hold true if we consider the amount used in Germany separately from that consumed in foreign countries. In Germany the natural minerals, kainite and sylvinite, are preferred for agricultural purposes while in other countries the preference is given to potassium chloride on account of its higher content in potassium. Of the total exports of 107,107 metric tons of potassium chloride in 1898, 63,667 tons, or almost two-thirds were consumed as fertilizers, while only 1,528 tons of a total of 70,877 tons sold by the Syndicate in Germany were utilized for this purpose. The remainder was manufactured into different chemical products as follows: 30,122 tons for the manufacture of potassium and caustic potash; 14,334 tons for the manufacture of saltpeter; 1,206 metric tons in the manufacture of bichromate of potassium; 763 metric tons for potassium chlorate and 4,471 metric tons for various other chemical compounds. In addition to these amounts 18,452 metric tons were consumed by the members of the Syndicate.

Carnallite, and to a lesser degree hartsalz and sylvinite, are the bases for the preparation of the potassium products. The chemical manufacturers are located in the vicinity of the mines. The first chemical works were established by A. Frank, in 1861, in the city of Stassfurt. The process used was based essentially on the fact that from a hot saturated solution of carnallite (KCl, $MgCl_2$, $6H_2O$) potassium chloride crystallizes out on cooling, while the magnesium chloride remains in solution. The process is carried out as follows: The crude salts are dissolved in large kettles which are filled with a boiling hot solution of magnesium chloride, whereby the rock salt and kieserite that may have been included in the crude salts remain undissolved. The solution, which has a sp. gr. of 1·32, is now allowed to run off in large crystallization pans in which, after two or three days, crystals containing 80% of potassium chloride with some sodium chloride are formed. To treat 1 ton of crude salts daily the crystallization pans must have on the average about 10 cu. m. capacity.

The most important of the secondary products of potassium chloride are potash and caustic potash. The Leblanc process is used in the preparation of potash, but in certain works the magnesia process, invented by C. R. Engel, has been adopted. Caustic potash is still prepared by the Leblanc method, but lately the electrolytic process is gaining ground, in which porous diaphragms of cement and a quicksilver electrode are used. By either process a very pure form of

chlorine is recovered as a by-product which is utilized in the preparation of chloride of lime. Another important use for potassium chloride is that of saltpeter manufacture. A large proportion of this is used in agriculture while a certain amount is consumed in the manufacture of black powder. Nitric acid is mostly imported in the form of Chile saltpeter.

An interesting fact deserving mention here is that in addition to potassium chloride, rubidium and cæsium are recovered in small amounts from the crude carnallite and sylvinite.

While the potassium chloride is utilized in the chemical industry for the preparation of potassium salts such as bichromate, chlorate, phosphate, silicate, cyanate and other salts, the natural sulphate minerals are also manufactured to some extent. A certain amount is used in preparing the double sulphate of potassium and magnesium containing 50% K_2SO_4 and about 2·5% Cl, which is consumed principally as a fertilizer. Pure potassium sulphate is also prepared by decomposing kainite by means of potassium chlorine according to the formula K_2SO_4, $MgSO_3+2KCl=2K_2SO_4+MgCl_2$. In Germany about one-third of the potassium sulphate is used in agriculture but of that exported more than seven-eights are consumed for the same purposes. A large part of the remainder is manufactured into alum.

Magnesium salts are prepared both from the kieserite and also from the sediment in the kettles used for dissolving the potassium salts. They are mostly marketed in the form of Epsomite, an important agent in the finishing of the thinner qualities of woolen goods.

Attempts are being made to utilize the magnesium chloride formed in manufacturing the other salts and which is allowed to go to waste. Small amounts have always been used as wash water in drilling, but it is probable that they will be more widely utilized in the future for the preparation of such chemical products as hydrochloric acid, chlorine, chloride of lime and ammonia and also of bromine, of which there is about 0·2% present. The preparation of hydrochloric acid is based upon the fact that magnesium chloride decomposes when heated in the presence of steam. Chlorine and bromine may be produced by electrolytic methods and the former placed on the market as chloride of lime.

In addition to the direct products already mentioned the chemical manufactories also prepare other products of more or less importance, notably oxalic acid and its salts, benzol, sykorine, urea, etc. The occurrence of nodules of boracite within the carnallite region is also of importance to the industry as considerable amounts of boric acid and boric salts are prepared.

A comparison of the statistics of production for the years 1857-1899, inclusive, which are given in THE MINERAL INDUSTRY, Vol. VIII., will readily show the wonderful importance which the German potassium industry has attained.

Potassium Cyanide.—The demand for this product increased largely during 1900 and its consumption in this country is estimated at about 1,500 tons, the greater part of which is utilized for the extraction of gold by the cyanide process. The imports of potassium cyanide in 1900 amounted to 2,034,174 lb., valued at $464,156, against 1,715,745 lb., valued at $381,973 in 1899, and were made by The Roessler & Hasslacher Chemical Co. and Schoellkopf, Hartford & Hanna

Co., who handle the product manufactured by the Gas Light & Coke Co., of London, and Fuerst Bros., Germany. The present revised import duty is 12·5% *ad valorem.* The market prices fluctuated but little throughout the year. Wholesale quotations in New York for 98 to 99% potassium cyanide were 28@30c. per lb. falling at the close of the year to 28c.

According to Gilpin* the supply of potassium ferrocyanide in Europe is mostly obtained in the purification of coal gas, although the method of heating organic matter with potassium carbonate and iron is still employed in three German and some English and American works. The cyanogen compounds present in the gas are absorbed by the mixture of calcium hydrate and iron sulphate used to remove the hydrogen sulphide. The mass, after having been exposed to the gas for some time, contains iron sulphide, sulphur, lime salts, free lime and iron and ammonia, ferrocyanides and sulphocyanides. After removing the soluble portions by washing with water, the mixture is treated with lime to form calcium ferrocyanide which is then converted by the action of potassium chloride into an insoluble compound of potassium and calcium ferrocyanides, which is decomposed by potassium carbonate with the formation of potassium ferrocyanide. In one English factory the cyanogen compounds are collected by passing the gas through a solution of iron sulphate, and the Prussian blue thus obtained is decomposed by treatment with caustic potash. In a German factory cyanogen compounds are formed from the decomposition of trimethylamine by heating "vinasses." These compounds are then converted into Prussian blue and treated with caustic potash as in the other method. About one-half of the 10,500 tons of potassium ferrocyanide produced in France, Germany, England, Belgium, Holland and the United States in 1899 was converted into potassium cyanide. Potassium sulphocyanide is also prepared from compounds found in coal gas. The comparatively small quantities obtained are mostly converted into a copper salt which forms a constituent of a paint used to protect the hulls of ships from fouling. The Roessler & Hasslacher Chemical Co. manufactures potassium cyanide by treating potassium ferrocyanide with sodium which yields a mixture of sodium and potassium cyanides and iron. By washing and crystallizing this product the substance sold under the name of potassium cyanide is obtained.

Saltpeter.—Potassium nitrate or saltpeter is produced exclusively in India by refining the crude salt obtained from the soil. The production of saltpeter in India during 1894-1899 is given officially as follows:

PRODUCTION OF SALTPETER IN INDIA. (IN LONG TONS.)

District.	1894.	1895.	1896.	1897.	1898.	1899.
Bengal	11,852	10,928	14,848	11,692	9,244	8,500
Madras	535	307	821	474	1,729	2,027
Punjab	90	180	216	451	544	690
Totals	12,477	11,415	15,885	12,617	11,517	11,217

The value of the production in India in 1899 was 1,635,465 rupees ($338,540). There has been a gradual decrease in the production during the past four years.

Potassium Chlorate.—The production of potassium chlorate in the United

* *American Chemical Journal*, December, 1900.

States in 1900 showed a large increase over previous years. While exact figures are not available it is estimated that the total production in 1900 amounted to 60,000 kegs each of 112 lb. The principal producers were the National Electrolytic Co. and Oldbury Electro Chemical Co. at Niagara Falls, N. Y., and the North American Chemical Co., at Bay City, Mich.

The increased production and the high ocean freight rates have lessened the imports of potassium chlorate appreciably. Domestic potassium chlorate in crystals sold at \$8·25@\$10·35 per 100 lb., and powdered at \$8·25@\$10·50; the lowest price was for 1901 contract deliveries. Foreign crystals sold at \$9·25@ \$10·50, and powdered at \$9·50@\$11·25, in New York. In England, makers quoted 3·75@4·5d. (7·5@9c.) per lb., f. o. b. Liverpool.

The National Electrolytic Co. has installed a second unit to its original 1,100 H.P. plant, making a total of 2,200 H.P. now available for the production of potassium. The company operates the Gibbs process* which consists of the electrolysis of an alkali or alkaline earth chloride in solution. This is passed continuously between two properly protected electrodes in a cell, the current density being sufficient to maintain a temperature suitable to the decomposition of hypochlorites and the flow of solution regulated to keep the temperature below 200°F. The capacity of the cell is from 2 to 4 cu. m. per sq. in. of electrode surface and the density of the current is from 2 to 4 amperes per sq. in. of electrode surface. The electrodes are protected from the action of chlorine by platinum or other resistant material, the protected cell wall forming the anode and vertically suspended wires or rods constitute the cathode.

The Manufacture of Potassium Chlorate by the Liebig Process.

By John B. C. Kershaw.

The ordinary chemical process used for the manufacture of potassium chlorate is based upon the reactions (first discovered by Liebig) which occur when chlorine gas acts upon a hydrate of the alkali metals, or upon hydrates of the alkaline earths, at an elevated temperature. The hydrate used is that of calcium. Five-sixths of the chlorine taking part in this reaction forms chloride, and only one-sixth is converted into chlorate. Were potassium or sodium hydrate used, over 80% would thus be converted into the corresponding chloride, and the re-conversion into hydrate would be both troublesome and costly. By using calcium hydrate, calcium chloride is obtained as a by-product of the first stage of manufacture; and calcium hydrate being comparatively inexpensive, this calcium chloride is allowed to run away as a waste product. In order to produce the potassium salt from the solution of calcium chlorate obtained in the manner described above, it is simply necessary to boil the solution with the amount of potassium chloride that analysis and calculation have proved to be requisite.

The chemical reactions which occur in this method of chlorate manufacture, may be represented by the following equations:

(1) $6Ca(OH)_2+6Cl)_2=3Ca(OCl)_2+3CaCl_2+6H_2O.$
(2) $3Ca(OCl)_2=Ca(ClO_3)_2+2CaCl_2.$
(3) $Ca(ClO_3)_2+2KCl=2KClO_3+CaCl_2.$

* United States Patent Nos. 665,426 and 665,427, both of Jan. 8, 1901.

The first reaction takes place in the vessels known as "absorbers" or "octagons," in the cold; the second occurs when the contents of the absorbers begin to heat, and the third takes place in the boiling-down pans, after the original solution of calcium chlorate has undergone concentration.

The potassium chlorate which crystallizes out from these crude chlorate liquors is contaminated with iron and other impurities, and further operations are necessary before the practically pure chlorate of commerce is obtained. These, however, involve no chemical changes, and the chemistry of chlorate production by the ordinary process, is covered by the equations given above. The manufacture of chlorates is thus seen to be based upon two comparatively simple chemical reactions, and the difficulties met with are of a mechanical, rather than of a chemical nature. The mother liquors, at the various stages of the process, all contain dissolved chlorate, and successful manufacture depends chiefly upon the skill and completeness with which these are dealt with, in order to reduce the losses of chlorate to a minimum. In the following account of the process and apparatus used, considerable space will therefore be given to the methods used for treatment of the mother liquor from the crude crystal pans, and from the refined crystal vats. It is no exaggeration to state, that the financial success of the manufacture depends solely upon the economy and efficiency of the system of dealing with these liquors; and in many cases a skillful chemical engineer with an eye to this side of the manufacture will attain better results, than a chemist whose attention is directed chiefly to the chemistry of the process.

Raw Materials.—The equations given above show that the raw materials requisite for the production of potassium chlorate are the following: Water, caustic lime, chlorine gas, and potassium chloride.

Water.—The water supply used for chlorate production must be carefully watched. For the crystallizing operations especially, it is necessary to exercise great care, and to use water quite free from suspended impurities and from dissolved sulphides. Sulphates, from their liability to be reduced by organic matter to sulphides, may lead to discoloration of the crystals from the refining vats, and therefore it is advisable to make use of a water free from these salts also. The presence of iron and of carbonates is also to be avoided, though these impurities are less harmful in their effects than sulphates and sulphides. As a rule it will be found advisable to have two or more sources of water supply; and to use only the purest water for the refining operations.

Caustic Lime.—The milk of lime used in the absorbers is generally prepared in a concentrated form in separate vessels, fitted with agitators and strainers for removal of the coarser particles. It is advisable to use only the best qualities of lime for preparation of the milk, since considerable losses result when badly burnt limestone is employed. The milk of lime should also be used in the absorbers without undue delay, as it is capable of absorbing carbonic acid gas from the atmosphere, and the presence of carbonate leads to loss of chlorine.

Chlorine.—It is outside of the scope of the present article to describe in detail the methods of chlorine gas generation usually employed in the chemical manufactories where chlorate is made. It may be stated, however, that the hydrochloride acid produced as a by-product in the manufacture of "salt cake" (sodium

sulphate) is the source of the chlorine, and that this is decomposed either by the catalytic action of salts of copper at high temperatures (the Deacon process) or by manganese dioxide in the form of Weldon-mud (the Weldon process). The chlorine gas thus obtained, contains carbonic acid gas, hydrochloric acid gas, and steam as impurities; but it is used without any attempt to remove these, beyond the purifying effect produced by slight cooling in the stoneware or lead pipes leading to the absorbers. Weldon-mud gas is much the stronger of the two, containing on the average 25% chlorine, while Deacon gas is reported to average only 9% chlorine.

Potassium Chloride.—The potassium chloride used in the manufacture of chlorate, is obtained from the Stassfurt marine-salt deposits near Magdeburg, in Germany. The salt obtained from these deposits comes into commerce containing 90 to 93% KCl, and is known in the English chemical industry as "muriates."

The following analyses* show the average composition of this salt:

COMPOSITION OF STASSFURT "MURIATES."

	I.	II.	III.		I.	II.	III.
	%	%	%		%	%	%
Water	4·26	3·62	4·72	$CaCl_2$	0·27	0·17	0·26
Organic matter	0·06	0·04	0·06	$MgCl_2$	0·79	0·45	0·63
Insoluble and Fe_2O_3	0·17	0·14	0·16	NaCl	0·58	2·41	2·81
Al_2O_3	0·47			KCl	93·01	92·28	90·23
$Al_2Si_2O_{12}$	0·29	0·10	0·12				
Na_2SO_4		0·25	0·45		99·90	99·46	99·44

PLANT AND MACHINERY.—The vessels used for carrying out the reaction between the chlorine gas and milk of lime are known as "octagons" or "absorbers" and are large closed vessels, built of Yorkshire flagstones, or of heavy iron castings, the joints in the former case being made with rubber cord, and the whole being firmly clamped together with cast-iron angle-irons, and tie rods. Each absorber is provided with openings in the top for the supply and exit of the chlorine gas; with a manhole for charging, cleaning out, and repairing purposes; with two run-off cocks at different levels; and with a gauge glass for indicating the height of the liquid. Each absorber is further provided with an agitating apparatus, worked by spur wheels and shafting from a stationary engine. Arrangements must be made whereby the connection of each absorber to the chlorine main supply pipe and to the main exit pipe can be made or broken at will; and each absorber must also be in connection with the milk of lime storage tank, and with the water mains.

Figs. 1 and 2 show a typical absorber in plan and sectional elevation, while Fig. 3 is a diagram of a set of four absorbers, with the chlorine supply and exit pipes.

The method of working is as follows: Milk of lime and water are run into the absorber and the agitator is set in motion. The height of the charge must be sufficient to close the hydraulic lutes of the agitator shaft and of the manhole; but not sufficient to cause frothing over, when the chlorine absorption commences.

* From *Chlorsaures Kali*, Jurisch, Berlin, 1888.

As a rule two-thirds is the limit beyond which it is unsafe to pass. The strength of the milk of lime when the absorber is fully charged should be 1·085 to 1·100 sp. gr., or about 113 gr. CaO per liter. As already pointed out, it is

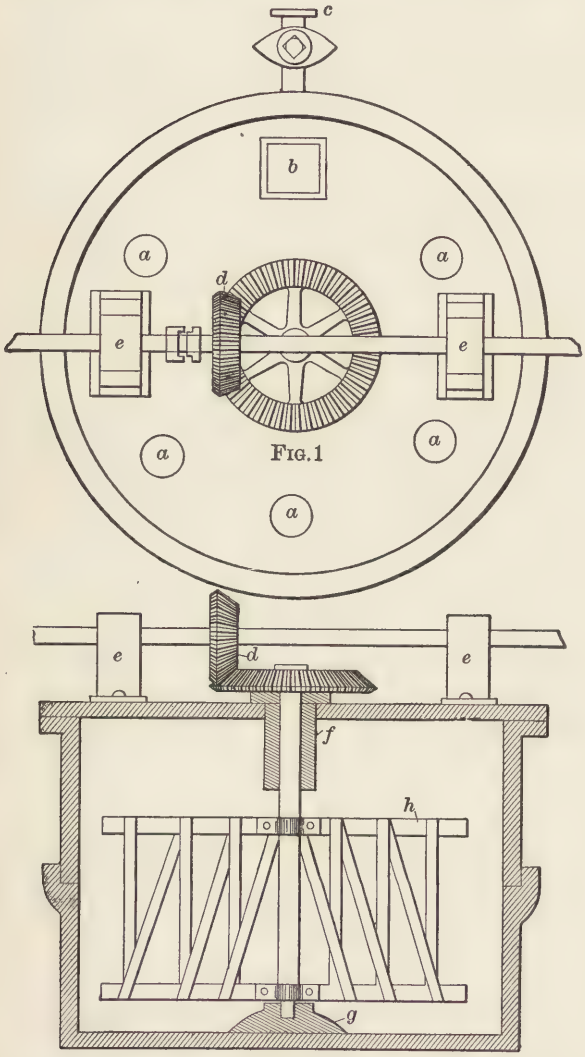


FIG. 1

FIG. 2

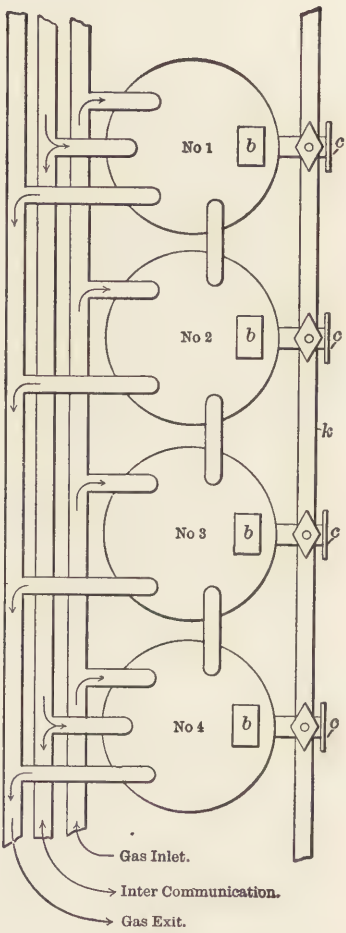


FIG. 3

FIGS. 1 AND 2.—PLAN AND SECTIONAL ELEVATION. FIG. 3.—SET OF FOUR ABSORBERS WITH CHLORINE SUPPLY AND EXIT PIPES.

a. Gas inlets and outlets.
b. Manhole.
c. Run-off cocks.
d. Spur wheel.
e. Shaft bearing.
f. Agitator lute and journal.
g. Agitator foot step.
h. Agitator framework.
k. Run-off channel.

advisable to prepare the concentrated milk of lime in a separate vessel, and to charge the absorbers as required, by pumping. If these be charged with lime

direct, it is necessary that it should be slaked and sieved beforehand. The connections with the chlorine main supply and exit pipes are now made, and the absorption is allowed to commence. A gradual rise of temperature accompanies this reaction, and the temperature must be noted from time to time, as if 40°C. be exceeded the proportion of chlorine to chlorate in the finished liquid will be increased. The temperature can be regulated by diminishing or increasing the supply of chlorine; and if the temperature should exceed the limit named, the supply of gas can be entirely cut off for a time. The absorption of chlorine and production of hypochlorites and chlorate is accompanied by the formation of a pink tinge in the clear liquid, due to the presence of manganese in the lime, and to formation of permanganates. The finishing of a single charge lasts from 12 to 30 or more hours, according to the capacity of the absorber, and to the strength of the chlorine gas.

Rough laboratory tests are made during the course of the absorption, and when the addition of dilute hydrochloric acid to a filtered sample of the charge, ceases to cause any effervescence or any evolution of gas, the absorption is considered to be finished. This test is based upon the fact that hydrochloric acid decomposes hypochlorites with evolution of chlorine, and the absence of effervescence therefore indicates that all hypochlorite has been converted into chloride and chlorate.

The chemical equations already given show that in the absorbing operation, six atoms of free chlorine are required to obtain one molecule of chlorate. The theoretical proportion of chlorine as chloride, to chlorine as chlorate, yielded by this method of production, is therefore 5 to 1. In actual practice, however, owing to various causes, the ratio is generally 5·3 to 1; and with bad work and bad management it may rise to 6 to 1.

Slow absorption with weak solutions, is most favorable to good chemical results. On the other hand quick absorption with concentrated solutions leads to important savings in time and fuel; and the question as to the best strength at which to run the absorbers is one the answer to which partly depends upon the price of coal.

It is usual to work the absorbers in sets of three or four, and to allow the chlorine gas to pass from that nearly finished, *toward* that newly charged with fresh milk of lime. The gas which escapes from the last absorber of the series is then conducted to some form of absorbing tower, through which it passes before escaping to the chimney. Fig. 4 gives a sectional elevation of one of the most useful forms of these milk of lime towers, for removing the last traces of chlorine from the exit gases.

The chief disadvantages of stone absorbers are: that they are costly to build, the joints are apt to leak, and it is difficult to work all the agitators with one line of shafting, owing to irregular subsidence of the foundation. They are also not very well adapted for use with the chlorine gas generated by the Deacon process, and only give good results with the stronger Weldon-mud gas. The two former difficulties can be overcome by use of smaller vessels of cast-iron with fewer joints. (See Figs. 1 and 2.) In order to overcome the latter difficulty, other forms of absorber have been proposed and tried; and the more important

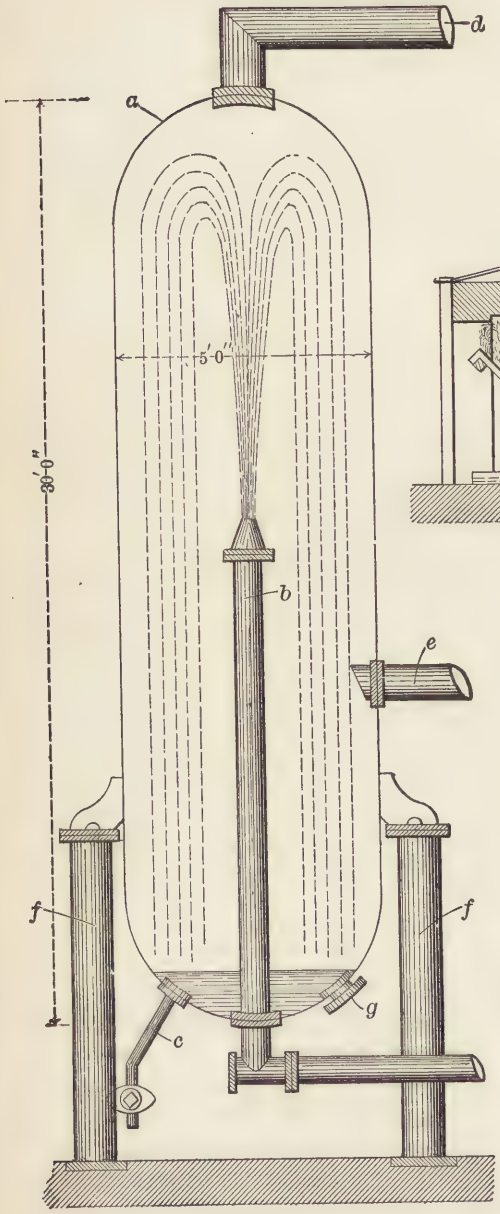


FIG. 4

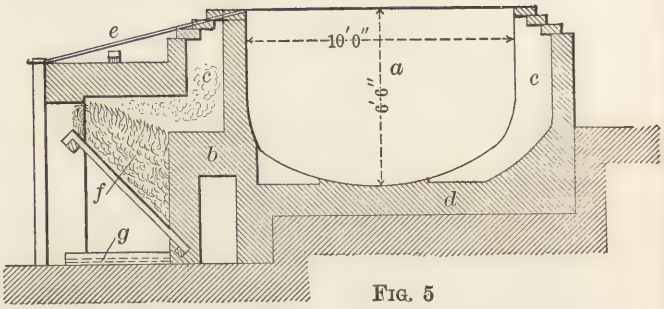


FIG. 5

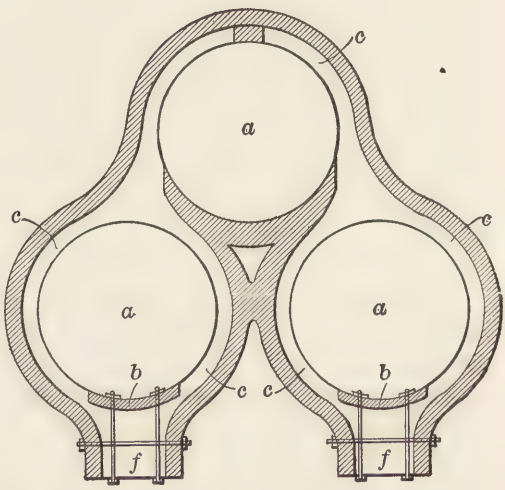


FIG. 6

FIG. 4.—ABSORBING TOWERS. SECTIONAL ELEVATION.

FIGS. 5 AND 6.—BOILING-DOWN PANS. SECTIONAL ELEVATION AND CROSS SECTION.

a. Wrought-iron shell.
b. Delivery pipe.
c. Run-off pipe.
d. Gas inlet.
e. Gas exit.
f. f. Supports.
g. Manhole.

a. Pot.
b. Breast-work.
c. Flue.
d. Foundation.
e. Tie-rod.
f. Fire-place.
g. Ash-pit with water-tray

of these will now be shortly described. Kuhlmann's absorber was first designed for the production of hypochlorites, and was tried in 1881 by Muspratt, of Widnes, for chlorate production. It is a circular vessel built of wrought-iron plates, and lined with lead. Its peculiar feature is that the chlorine enters at one side near to the bottom, and that it is conducted upward by an inverted leading channel running round the inner walls of the absorber in spiral fashion. The milk of lime is kept in agitation by the usual form of mechanical stirrer. An injector-pump working under 50 lb. steam-pressure is required on the exit pipe, when using this form of absorber, in order to draw the chlorine through the milk of lime; and the ordinary hydraulic lutes are insufficient to close the openings in the cover of the absorber. Another disadvantage is that the lead channel is quickly eaten away at its lower end, where the chlorine first enters the absorber. Owing to these disadvantages this form is no longer used for chlorate production.

Kunheim's absorber is a vessel of iron provided with internal flanged shelves, intended to retain a shallow layer of milk of lime, when in operation. The milk of lime passes constantly from above downward, and each shelf is provided with a mechanical agitator. The chlorine enters below, and passes in zigzag fashion over the surface of the lime. Four or five of these towers are worked in series, the milk of lime being pumped from one to the other. This absorber was originally built of cast-iron plates, but these were attacked by the chlorine and hypochlorite, and the writer is informed that glass is about to be tried as a substitute for iron.

The difficulty with Deacon gas has also been overcome, by the bold method of covering in the air-cylinder of a Weldon blowing engine, and connecting this with the chlorine supply main, and with the absorbers. The weak chlorine gas was thus blown through the milk of lime and mechanical agitation dispensed with; but although rapid work and absorption were obtained in this way, the chlorine gas acted too destructively on the cylinder of the engine. For Weldon-mud gas, the old form of stone or cast-iron absorber is therefore still the best. For Deacon gas one of the numerous forms of shelf-absorbing tower is generally adopted.

Settling Pans.—The contents of the absorbers when finished are run off into settling pans, and from 3 to 7 hours are allowed for the insoluble matters: sand, calcium carbonate, and calcium hydrate to settle. The settling pans should be equal in capacity and number to the absorbers; since owing to the necessity for accumulating and washing the lime mud which separates in them, their actual capacity is always less than their nominal. These pans are usually built of boiler-plate, and have their sides supported by transverse ribs and tie rods. Each pan must be connected with the water supply, and be provided with a swivel-joint run-off siphon, and a large cock for sluicing-out purposes.

It is customary for the clear chlorate solution to be pumped to a higher level at this point in the process, so that gravitation may carry it through the next two stages. An ordinary double-barrel force-pump, with gun metal barrels is generally used. If this pump be placed on a foundation above the level of the settling pans, the somewhat troublesome swivel-joint pipes may be dispensed

with, and a length of 6-in. flexible rubber hose pipe may be used to suck the chlorate solution from any tank into the pump valve boxes. Care must be taken that no lime is carried off with the clear solution, and that only well-settled chlorate liquor is pumped into the storage tanks; for if lime gets into the crude crystal pans, much trouble may ensue.

A consideration of the principles of gravitation will show that the quicker settling must occur with the weaker solutions; and practice in this respect supports theory. Up to 1·150 sp. gr. the chlorate liquors settle well; but beyond this limit, settling is slow, and this is the chief obstacle to the use of stronger lime charges in the absorbers. Trials have been made in England with absorber charges testing 1·30 and 1·35 sp. gr., but a filter-press was required to separate the clear solution of calcium chlorate from the unaltered residue, and the experiment was not an economical success. Charges testing 1·20 to 1·25 sp. gr. (clear solution finished) are even now being worked, but a long time is required to obtain good settling with these.

The lime residues are allowed to accumulate in the settling pans until they are half full, when two or more washes with water are given, and the weak solutions of calcium chlorate obtained in this way are used in place of water, in one of the newly charged absorbers. The lime mud is finally sluiced out by the bottom opening in the pans, and is either regarded as a waste product, or is used in the semi-dry state for neutralizing purposes.

The Boiling-down Pans.—The next operations in the manufacture of chlorate are to add the required amount of potassium chloride to the calcium chlorate liquors, and to boil down the resultant solution until the strength is reached at which separation of the greater part of the chlorate by crystallization can occur. The boiling-down operation takes place in pots or pans, so arranged that a maximum evaporative effect is obtained from a given weight of fuel. In many factories wrought-iron pans are used for this operation, but in the writer's opinion cast-iron pots similar to those used for caustic manufacture are more suitable since considerable erosive action occurs at the point where the air and liquid meet. Figs. 5 and 6 show the arrangement adopted for setting a group of these pots; the third pot in this arrangement being heated by the waste flue gases from the other two.

The solution of calcium chlorate which is to be used is carefully measured, sampled, and tested by the chemist in charge of the chlorate manufacture, and the weight of potassium chloride necessary to decompose the calcium chlorate present is calculated.

It is customary to add from 1 to 3% excess of the salt, unless the mother liquors from the crude crystal pans are intended to be used for chlorine generation, in which case *less* than the calculated weight is added. The addition of the main portion should be made as soon as the contents of the boiling-down pot are warm; and it is advisable to have a separate supply tank for each boiling-down pot, and to measure, sample, and test the calcium chlorate liquor in this tank rather than in the pot itself. If this course be impossible, the measurements and tests must be made upon the liquor contained in the pot during the last hour of the boiling-down operations, and the required addition of the potassium

salt (over and above that which has already been made) worked out upon these results.

Jurisch has stated* that considerable loss of oxygen occurs during the boiling-down operation. Lunge has, however, contradicted† the assertion made by Jurisch on this point, and the writer, during his own experience, has not met with any evidence of such decomposition. Many samples of concentrated calcium chlorate liquor have been tested by him, and the proportion of chlorine as chloride, to chlorine as chlorate, has rarely exceeded 6 to 1; whereas Jurisch states that 11 to 1 is often found.

The strength at which the liquor is baled off into the crude crystal pans, varies with the time of the year, and with the temperature of the surrounding atmosphere. In summer a sp. gr. of 1·31° (hot) is usually obtained; while in winter a slightly lower degree of concentration is sufficient. These figures represent average working strengths in England; in Germany the climatic changes are more severe and greater variation would be necessary.

The Crude Crystal Pans.—These are wide shallow V-shaped pans constructed of boiler plate and supported on transverse brick walls, a few inches above the floor. The building in which they are placed should be large and well ventilated,

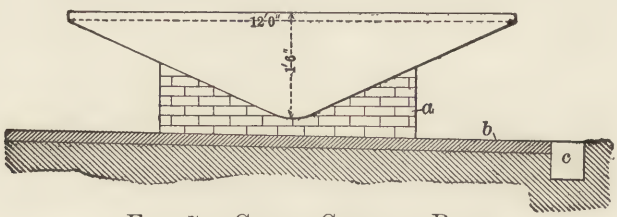


FIG. 7.—CRUDE CRYSTAL PAN.

a. Brick support. *b.* Brick and cement floor. *c.* Run-off channel.

and should possess a double bricked floor draining toward a longitudinal central channel, by which the waste mother liquor and drainings from all the pans can be conducted to a catch vessel of iron, sunk in the ground at one end of the building. Each pan is provided with a run-off pipe and plug, at its lowest point. Fig. 7 is a sectional elevation of one of these pans. The pans should be of such dimensions that two are completely filled by the contents of one boiling-down pot. The time required for the mother liquor to attain the temperature of the surrounding atmosphere, varies from 6 to 10 days, being much the shorter in winter. The mother liquor, which contains principally calcium chloride, is usually about 1·35° sp. gr. and contains from 10 to 35 gm. of chlorate per liter, as potassium or calcium chlorate. In recent years, artificial refrigeration has been applied with some degree of commercial success to these mother liquors, and in England all crude crystal mother liquors are now treated in this way, and the contents thereby reduced to less than 8 gm. potassium chlorate per liter. Care is of course necessary to prevent calcium chloride from crystallizing out with the chlorate, but the writer believes that a temperature of —15°C. can be approached without danger. The following tests of crystal obtained in this way are of interest:

* *Chlorsaures Kali*, Jurisch, Berlin, 1888. † *Sulphuric Acid and Alkali*, Vol. III., Lunge, London, 1896.

	I.	II.	III.		I.	II.	III.
	%	%	%		%	%	%
KCl	1·4	2·0	1·8	Insoluble	2·7	2·6	1·0
$CaCl_2$	1·1	1·2	6·2	$KClO_3$	88·1	90·6	75·8
H_2O	0·3	3·3	13·5				

The alternative method of treatment is to use 90% of the calculated weight of potassium chloride in the boiling-down pots, and to use the mother liquor from the crude crystal pans (which in this case will contain most of the chlorate present in the form of the calcium salt) in the chlorine stills for chlorine generation. Lunge states that the treatment of this liquor with hydrochloric acid is troublesome, and in some cases has been discontinued; but the writer has evidence that the method was in use in South Lancashire comparatively recently.

The crystals found in the crude crystal pans are needle-shaped in form, and are contaminated with much oxide of iron from the boiling-down pots and crystallizing pans, and with much calcium chloride. They are allowed to drain well before removal from the pans, and should then, when well pressed together, weigh about 86·25 lb. to the cubic foot, and contain about 80% of potassium chlorate. They are placed in a centrifugal machine, washed with water, and partially dried in the same. This operation removes most of the iron and of the calcium chloride. The washed crystal is now ready for the refining operation.

Refined Crystal Vats.—The washed crude crystal from the centrifugal machine is brought into solution again with the aid of steam in a vessel called the "dissolver." This is a large cylindrical vessel constructed of boiler-plate and lined with lead. It is useful to have it cased-in by some non-conducting material, to prevent loss of heat by radiation. It should be provided with a perforated lead box for holding the crude crystal near the surface of the water; with a swivel-joint run-off siphon; and with a sluicing out cock, or manhole, at its lowest point. The dissolver is placed at such a height that the solution of chlorate can be run from it by gravity into the refined crystal vats; and its capacity should be such that four of the latter can be completely filled at each operation. The water used for this and the subsequent operations in the refining house should be the purest obtainable. The strength at which the solution of chlorate is run into the refining vats varies with the season, it being necessary to work with less concentrated solution in winter. The usual sp. gr. is 1·10 to 1·11 (hot) and at this strength the solution contains about 14 lb. potassium chlorate per cu. ft. The refined crystal vats, into which the solution must be run as hot as possible, are placed in a separate building, in which scrupulous cleanliness must be observed. The vats have in the past always been constructed of wood and lined with lead, and wooden roof spans have in many cases been used for this and the neighboring buildings. As a result of the disastrous explosion of chlorate of potash at St. Helens, England, in May, 1899, chlorate has been recognized as an explosive under certain conditions; and wood will now have to be banished entirely from all buildings in which chlorate is made or stored.* The substitution of iron for wood will, however, take some little time to effect, and some modification in the design of the vats, etc., is likely to be made. In the following the old form of lead-lined wooden

* See note on this explosion, THE MINERAL INDUSTRY, Vol. VIII., p. 488.

vat is therefore described. The vats are rectangular in form, and a size yielding good results is 5×4×3 ft. deep. In some cases they have been made with V-shaped bottoms, to promote draining away the mother liquor when the contents are to be emptied. A more satisfactory plan is to design them with flat bottoms and to mount them on two low brick walls, the front wall being 2 in. lower than the back wall. By raising them off the ground, the detection of leakage is made more certain, and cooling is promoted; while the slight inclination enables the crystals to be drained by gathering them at the higher end of the vats. Each vat is provided with a lead plug fitting into an antimony seating, and if these are not quite tight when the vats are first filled, crystallization speedily stops the leakage. The building containing these vats must be large and well ventilated; and, as in the crude crystal house, the floor should be double bricked, and have a fall to the two or more lines of iron shoots or channels, by which all leakage, and also the mother liquors, can be conveyed to a catch vessel sunk in the ground at one end of the building. This vessel must be provided with a small pump and with the necessary pipe connections, for pumping the mother liquor back into the dissolver, or, when it has become charged with impurities, into a separate storage tank near to the boiling-down pots. Strict measurement should be kept of all the mother liquors passing through this vessel; otherwise leakage into the ground from the run-off channels and much loss of chlorate, may occur unnoticed. At least eight days are necessary for cooling, to obtain the best results with vats of the dimensions named above, and therefore the refined crystal house must accommodate a very large number of these vats. In the chlorate works of which the writer had charge, an output of six tons chlorate per week was obtained from 10 crude crystal pans and 30 refined crystal vats. In order to promote the formation of large crystals, wooden laths are placed in the refined crystal vats; these become covered with crystals as the solution cools. The formation of large crystals is also promoted by slow cooling, and to this end, and also to keep dust and dirt out of the vats, it is useful to have light covers for the same, and to keep them covered for the first four or five days.

The filling of the vats is best carried out by a lead-lined open shoot, supported a few inches above each row of vats, and provided over each vat, with a delivering pipe and lead plug. The delivery of the concentrated solution of chlorate from the dissolver into these shoots, takes place by a 3-in. steel pipe, provided with the necessary stop-cocks. It is absolutely necessary to arrange this pipe with a good fall, and to drain it empty after each discharge of refined chlorate liquor; since if the solution be left in the pipe, it will become blocked throughout its entire length with chlorate crystals. It is also advisable to have this pipe connected near the dissolver to a 0·25-in. steam-pipe, in order that before using, steam may be blown through to heat it and thus lessen the risks of any stoppage through crystallization.

The yield of refined crystal from these vats depends greatly upon the period of the year, fully one-sixth more being obtained during the cooler months in England. In the United States the variation in yield will be much greater. The sp. gr. of the mother liquor from the vats varies between 1·04 and 1·08 (at 1·060 sp. gr. it contains between 60 and 70 g. chlorate per liter) and *until* the latter

limit has been reached, it is used in place of water in the dissolver for making up the solution for the refining vats. When a sp. gr. of 1·08 has been exceeded, owing to the accumulation of chlorides and other impurities, the mother liquor is pumped into the special storage tank provided for it near to the boiling-down pots, and when sufficient has been collected here, a special boil is made with this solution. The concentration is allowed to proceed until a sp. gr. of 1·20 has been attained, and the liquor is then baled off into the crude crystal pans. No addition of potassium chloride is required. The mother liquor from this crystallization is returned to the pot and is boiled down to a sp. gr. of 1·35 and is again put into the crude crystal pans. The final mother liquor should be pumped into a small tank, and be used for feeding the ordinary boiling-down pots *after* the addition of the potassium salt, and just before baling off.

Treatment of Crystals.—The crystals of chlorate obtained from the refined crystal vats are different in form from those obtained in the crude crystal pans, being thin, transparent, and foliated, and in some cases showing a peculiar iridescent play of color on their surface when held at certain angles. The crystals are allowed to drain well in the vats, and are then removed in sieves by hand labor to the washing table. This table should be of considerable size (20×5 ft. for an output of one ton chlorate per day) and should be covered with lead. It should have a 2-in. flange all around it. A plentiful supply of water, free from suspended matter, sulphides and chlorides, should be provided for washing purposes. The surface of the table should be slightly inclined toward one corner, and the washings carried off from here to the catch-well. These washings are used in the dissolver in place of water, for dissolving the crude crystals. Considerable experience is necessary to obtain the greatest efficiency with a small expenditure of water in the washing operation, and as chlorate is slightly soluble in cold water, only a man with the necessary qualifications should be allowed to conduct the washing operations. Before the chlorate is removed from this table it is advisable to have samples tested for chloride; as if this exceeds 0·05%, further washing will be necessary. After washing, the chlorate crystals are gathered in a heap at the upper end of the table, and are allowed to drain for twelve or more hours. At this stage great care is necessary, especially in works where alkali is produced by the Leblanc process, to prevent discoloration of the washed crystal. Lead is always present in small amounts in the mother liquors, and if sulphides be present in the water, or hydrogen sulphide gas in the atmosphere, a brown skin of lead sulphide will be found upon the surface of the crystals. It is therefore advisable to keep the washed crystals covered with paper while they are left to drain upon the washing table. After thoroughly draining away all the wash water, the crystals are ready for drying. The operation is carried out upon the drying table, which with the grinding mill and sieve is usually placed in a separate building. The drying table is simply a shallow box-table constructed of boiler plates, a 2-in. upturned flange all around it, and covered with lead. The table is connected to the steam supply, and is provided with a steam-trap at its lowest point, to carry off the condensed water. A table with a superficial area of 120 sq. ft. will suffice for drying one ton chlorate per day, if the crystals be fairly well drained before removal from the washing table.

The best color and appearance are obtained in the finished crystal when these have been air dried on the latter, and when only a very slight heating is required to remove the last traces of moisture. Crystals put upon the drying table wet, are always frosted, a result due to the chlorate held in solution by the water clinging to them.

The greater portion of the chlorate sold is packed as crystal; but for many uses it is necessary to have it in the form of powder, and a few details concerning the method of grinding and sieving are therefore given. The form of mill used in grinding chlorate is shown in Fig. 8. The stones are about 26 in. diameter, and only the upper stone revolves. The chlorate crystal is fed in through the center of this stone automatically; the ground chlorate is delivered at the periphery of the lower stone. The mill is driven by belt and shafting, from an engine placed outside the building.

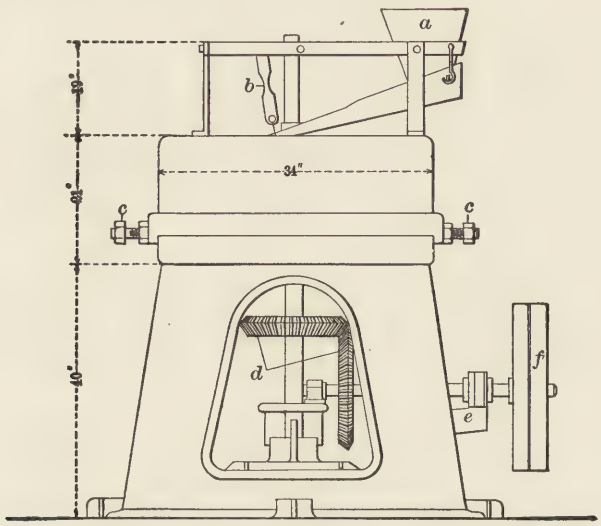


FIG. 8.—GRINDING MILL FOR CHLORATE.

a. Feed-hopper. *b.* Wood spring. *c.* Adjusting screws.
d. Spur wheels. *e.* Side bracket and journal. *f.* Driving pulley.

Grinding chlorate is considered the most dangerous of the operations involved in chlorate production, and a trustworthy and cool-headed man is required for the work. The stones of the mill require frequent cleaning and cutting to obtain the best results, and it is advisable to use the crystal direct from the drying table, as there is less tendency for the mill to clog when the crystals are put through it in a warm condition. The ground chlorate from the mill is put through the sieve which should be enclosed, and rocked mechanically. Here again the best results are obtained when the chlorate is warm.

The crystals and powder obtained as described above are now ready for packing. In the past small wooden barrels lined with paper, each holding 1 cwt. have been employed, but owing to the changed views respecting the explosive properties of chlorate when suddenly heated to a high temperature, it is probable that wood and paper will no longer be used for this purpose. The writer has

been informed that small sheet-iron drums have been tried and found wanting, since they will not stand storage and carriage, without collapse of their sides. The question of a suitable package for chlorate is therefore still unsettled. A separate storehouse for the finished and packed chlorate, at some distance from other buildings, is advisable.

The chlorate of potash of commerce rarely contains more than 0·06% of impurities, chiefly chlorides, and therefore the manufacture may be regarded as one demanding as much care and attention to detail, as that of pure or "fine" chemicals.

On account of the readiness of cotton and wool fabrics impregnated with chlorate dust to catch fire and burn with explosive rapidity, the workers in the refining and grinding departments of a chlorate factory are compelled to wear special clothing, and strict rules with regard to matches and smoking are necessary. It is also advisable to have in each of the buildings large tanks of water constantly filled, so that in case of their clothing becoming ignited, the men can put out the flames by simply stepping bodily *into these tanks.*

YIELD AND COST OF CHLORATE OF POTASH.—With reference to the consumption of raw materials per ton of chlorate produced by the Liebig process, there is some difference between the figures obtained by the two systems of working.

Jurisch considers that the most economical results are obtained when *less* than the theoretical amount of potassium chloride is added in the boiling-down pots, and the mother liquor from the crude crystal pans is used for chlorine generation in the stills. By this system an amount of potassium chloride is saved; while the consumption of lime, hydrochloric acid, fuel, and labor is increased. Working in this way 74·4% of the chlorate present in the pot liquors is said to be obtained as finished chlorate.* In the works of which I had charge, a yield much higher than this was obtained by using 5% excess of muriates; and as in this works at that date, it was not possible to use the crude crystal mother liquors for chlorine generation the method of working adopted was probably the best. Using the excess named the yield of chlorate averaged 82·2% of that present in the boiling-down pots; and the yield rose to 90% during the coldest month of the year when the mother liquors were reduced to near the freezing point of water.

I have no figures for the yields obtained by the method of working at present employed in English factories; namely, use of 1·5% excess of muriates, and artificial refrigeration of the mother liquors from the crude crystal pans; but as the mother liquors are said to be reduced to 3 g. potassium chlorate per liter, the average yield of finished chlorate probably exceeds 90% of that present in the boiling-down pots. The relative economy of the above three methods of work depends largely upon the relative costs of fuel, raw materials, and labor; and it can only be settled for each locality by actual trial.

For a fuller discussion of the consumption of raw materials, of yields of finished chlorate, and of costs, by the Liebig process of manufacture, readers are referred to the two books named below.† The following figures are, how-

* Jurisch, *Chlorsaures Kali*, p. 116.

† Lunge, *Sulphuric Acid and Alkali*, Vol. III., 1896; Jurisch, *Chlorsaures Kali*, 1888.

ever, derived from my personal notes, and have not before been published. They are of interest for comparison with the figures given by the authorities named, and with the results now being obtained in this manufacture in Europe and America.

CONSUMPTION OF RAW MATERIALS BASED UPON ACTUAL FIGURES FOR ONE YEAR'S WORK.

Fuel for boiling-down purposes	5·86 tons.	Per ton of Chlorate made.
Muriates, 96%	18·86 cwts.	
Lime—for absorbers and Weldon plant	7·025 tons.	
Manganese, 70%	4·2 cwts.	

The cost of chlorate of potash by the Liebig process varies considerably from year to year; the price of fuel and the coolness of the seasons having great influence upon the results. The cost may be taken to lie with efficient work—between $144 and $168 per ton—and it is therefore evident that when this chemical is selling at 6·5c. per lb. the margin for profit is small.

I am indebted to Dr. Jurisch and to Mr. Heyfelder for permission to use Figs. 3 and 4 as illustrations to the text of this article. These figures are from the 1888 edition of *"Chlorsaures Kali."*

Potassium and Sodium Chlorates and Hypochlorites during 1900.

By John B. C. Kershaw.

Chlorates.—The year 1900 has not been marked by any rapid growth in the electrolytic chlorate industry; the 20% rise in the price of potassium and sodium chlorates during the year having been due to the advance in the cost of fuel, and not to any noteworthy increase in the demand. The number of electrolytic chlorate factories in operation is now eleven, distributed as follows: United States, 3; France, 2; Sweden, 2; Germany, 2; Austria, 1; Switzerland, 1. The projected factory in the United Kingdom at Little Wenlock in Shropshire has not been proceeded with; but a new electrolytic factory has been built at Alby in Sweden, and this is now operating. The total power available for chlorate production by electrolytic methods is about 40,000 H.P., equivalent to a production of 12,000 tons of potassium chlorate per annum. As pointed out in The Mineral Industry, Vol. VIII., p. 485, it is improbable that the whole of this power is being applied to the production of chlorates. The older Liebig process described at length elsewhere in this section, is still being worked at Widnes and at St. Helens in England, and at two places in France; and the modification of this process patented by Hargreaves is also operated at one works in Cheshire. These five factories operating the chemical methods of manufacture, still account for about one-third of the total production of chlorates.

The chemistry of the chlorate cell continues to attract the attention of electro-chemists, and a large number of researches bearing upon it have been published in the German electro-chemical journals during 1900. Abstracts of many of these have appeared in *Science Abstracts;* limits of space will not permit them to be dealt with here.

The litigation between the public authorities and the United Alkali Co. in England, with reference to claims for damages caused by the disastrous chlorate explosion at St. Helens in May, 1899, has resulted in a verdict against the chemical company. This judgment should cause much greater care to be exercised in the manufacture of chlorates, and will lead to the use of iron in place of wood in all buildings intended for chlorate storage or manufacture.

Hypochlorites.—The use of solutions of hypochlorite produced by electrolysis for bleaching purposes, is slowly extending on the Continent of Europe. In southern Germany and in Russia a very large number of textile factories are now equipped with the electrolytic cells and apparatus for producing these solutions. In France, Austria, and Norway, the electrolytic bleach solutions are being used chiefly for bleaching wood-pulp, or cellulose. The cells most widely used, are designed and patented by Kellner, Vogelsang, and Oettel. Others in more restricted use, are patented in the names of Hermite, Stefanow, and Corbin. In nearly all of these, platinum is used as electrode material. This necessitates a high capital outlay for the apparatus, especially for large installations, and has retarded the more rapid growth of the industry. Oettel has recently described a hypochlorite cell designed by himself and Haas, in which specially prepared carbon plates are employed in place of platinum. These are said to have a life of six months with proper use, and to reduce greatly the first cost of the apparatus. Solutions containing up to 10 g. active chlorine per liter, can also be produced in the Haas and Oettel apparatus without great loss in electrical efficiency, and Oettel claims that this cell is the most satisfactory and efficient of any yet used for the industrial preparation of hypochlorite solutions.

It is impossible to give any very accurate estimate of the number of wood-pulp and textile factories in Europe now employing electrolytic bleaching methods; but from figures in my possession I believe that over 100 installations of this kind are in operation and that the number is growing. The horse power used is generally small—the largest installation of which I have details only utilizing 100 H.P.

Experiments are now being conducted at Bradford in England, with one form of electrolytic bleach cell, and if these should be successful, rapid adoption of the method in English textile works is likely to occur.

In the United States the Burgess Sulphite Fiber Co. is using a modification of the Le Sueur electrolytic alkali process for producing hypochlorite solutions at Berlin Falls, N. H., and is employing the solutions for bleaching wood-pulp.

At Havana, the Woolf cell for production of similar solutions from sea water has been in operation for about 18 months, the solution being used for disinfecting the harbor. A report recently published by the United States Army authorities, however, states that better results at less cost could have been obtained by the use of chloride of lime. This confirms the results of experimental trials with the Hermite disinfecting process at Ipswich, Lytham, Worthing and other places in England, early in the nineties. A study of the English literature on this subject might therefore have saved the expenditure upon the disinfecting plant at Havana.

QUICKSILVER.

THE production of quicksilver in the United States during 1900 amounted to 27,855 flasks, against 28,879 flasks in 1899. The decreased production during the past few years has been due to some extent to the almost complete cessation of gold mining and milling in South Africa, although the development of the Rhodin and other electrolytic processes for the manufacture of soda and chlorine has consumed an increased amount.

PRODUCTION AND EXPORTS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.			Exports.			Year.	Production.			Exports.		
	Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.		Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.
1895..	33,978	1,179	$1,313,589	15,542	539	$482,085	1898....	30,493	1,058	$1,109,945	12,830	445	$440,587
1896..	29,863	1,036	1,104,997	19,944	692	618,437	1899....	28,879	993	1,155,160	16,518	573	609,586
1897..	26,079	965	910,418	13,173	475	394,549	1900....	27,855	967	1.288,851	10,172	353	425,812

The imports of quicksilver during the past five years were as follows: 1895, $2,503; 1896, $2,037; 1897, 45,539 lb. ($20,147); 1898, 81 lb. ($51); 1899, 131 lb. ($83); 1900, 2,616 lb. ($1,051).

California.—The total production of quicksilver in this State during 1900 amounted to 25,922 flasks, against 28,618 flasks in 1899, and 30,116 flasks in 1898. The companies forming the syndicate have withheld their usual statement of individual production and therefore it is impossible to continue the detailed statistics which appear in previous volumes of THE MINERAL INDUSTRY. The price of quicksilver at San Francisco in January, 1900, was $51·50@$52 per flask for domestic and $47@$47·50 for export. These prices gradually declined during the year, closing out in December at $48 for domestic and $45 for export. London prices fluctuated but 10s. during the year, and ranged from £9 2s. 6d.@£9 12s. 6d. per flask. The Napa Consolidated Quicksilver Mining Co. produced 4,550 flasks, against 5,850 in 1899, this being the largest of the California mines. The total income was $211,883, of which $205,805 was received from sales of metal, while the net earnings amounted to $44,082 and the dividends to $50,000. A large amount of new territory was developed during the year, and the general condition of the mine showed improvement. The Ætna Consolidated Quicksilver Mining Co. produced 1,945 flasks from 11,888 tons of ore, against 3,800 flasks from 18,084 tons in 1899, a decrease of 1,855 flasks. The net earnings amounted to $18,540 and the dividends to

$15,000 or 3% on the capital stock. Ore in the upper levels of the river is practically exhausted, and prospecting has been carried on to locate a possible continuation of the lode, but as yet without much encouragement. The company has secured a bond on a new property which is being developed. The New Idria Quicksilver Mining Co. treated 20,638 tons of ore for a yield of 3,990 flasks, against 20,629 tons and 4,780 flasks in the previous year. From total receipts of $181,339 the net income, after charging $10,240 for depreciation, was $58,313. Dividends to the amount of $80,000 were paid, leaving a balance with that brought forward from the previous year of $44,572. Labor troubles during the summer months caused the reduction in the output of metal. Development work shows large bodies of ore in the lower levels, while the San Carlos claim has been prospected with favorable results. Construction of an additional furnace has been commenced which will doubtless add materially to the output. The Boston Quicksilver Mining Co. received $57,162 from sales of quicksilver and $19,168 from other sources, while the expenses amounted to $51,576; $20,000 in dividends were paid. The construction of the new furnace was hastened with a view of having it completed early this year, and it is intended to remodel the old one, bringing the combined furnace capacity up to 100 tons per day. No. 2 shaft has been sunk to a depth of 400 ft. and shows good ore. A new tram has been built to convey the ore to the furnaces. Oil was encountered at the 300 and 400-ft. levels and it is proposed to drill a well in the sandstone east of the mine.

RANGE OF QUICKSILVER PRICES PER FLASK AT SAN FRANCISCO IN 1900.

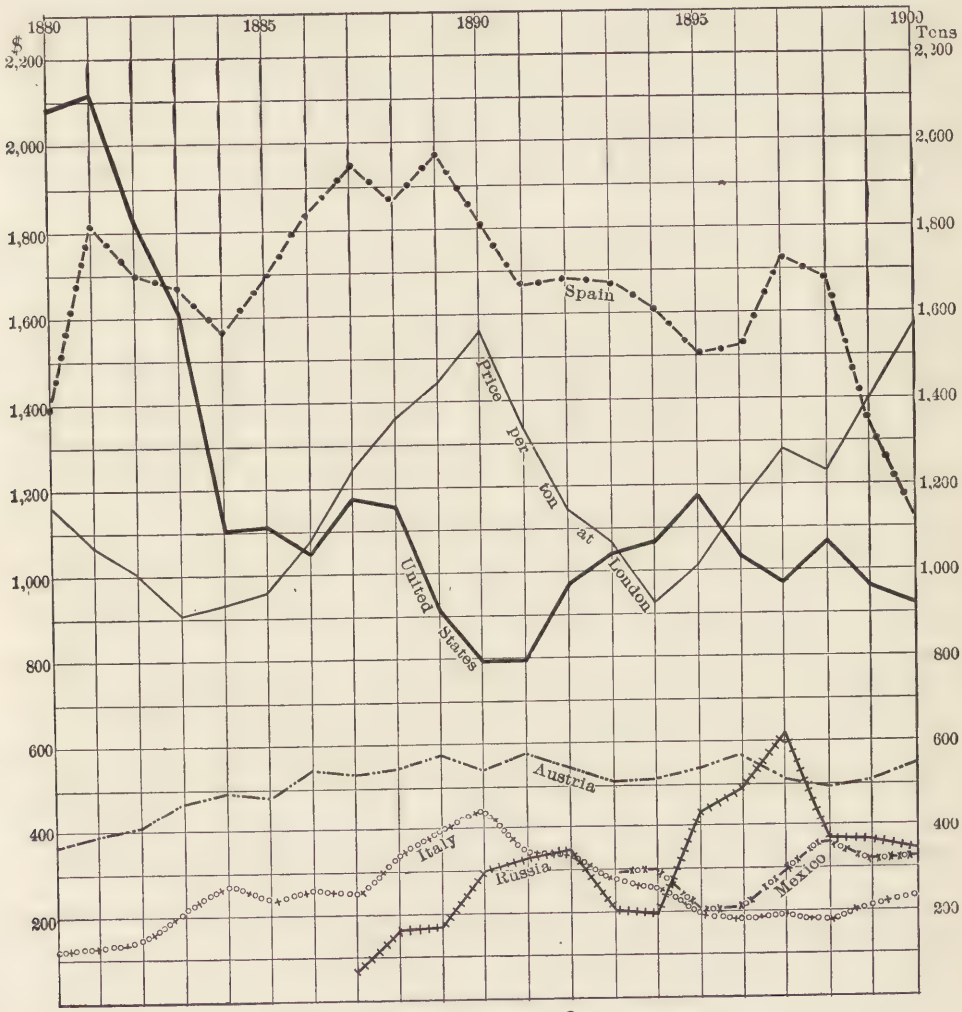
Month,	Domestic.		Export.		Month.	Domestic.		Export.	
	Highest.	Lowest.	Highest.	Lowest.		Highest.	Lowest.	Highest.	Lowest.
January	$52·00	$51·00	$47·50	$47·00	July	$51·00	$49·50	$47·00	$47·00
February	51·50	51·50	47·50	47·50	August	50·00	48·00	47·00	45·00
March	51·50	51·50	47·50	47·50	September	49·00	48·50	46·00	45·00
April	52·00	51·50	47·50	47·00	October	48·50	47·50	45·50	45·00
May	51·50	51·50			November	48·50	48·00	45·00	45·00
June	51·00	49·50	47·50	47·00	December	48·00	48·00	45·00	45·00

Nevada.—A discovery of rich quicksilver ore was reported from the Lone Pine district, but it has yet to be verified.

Oregon.—The Black Butte quicksilver mine in Lane County, reports a production of 233 flasks of quicksilver during 1900 and has acquired the 10-ton Scott furnace at Elkhead mine in Douglas County, 5 miles distant. Considerable development at mines and smelter is promised for 1901.

Texas.—The quicksilver mines are located at Terlingua, Brewster County, about 92 miles southeast of Marfa, a station on the Southern Pacific Railway, about 65 miles from Austin. The deposits embrace a territory of about 10×1·5 miles. The ores are cinnabar, native mercury and yellow sulphide which has been called "Terlinguaite." Pyrite with arsenic and manganese compounds are also found. The associated gangue is calcite, aragonite and a little barite. Cinnabar carrying as much as 84% Hg has been found, and rich pockets of 50% Hg have also been opened up. The chief properties in the district are the

Marfa & Mariposa Mining Co., the California mine, Excelsior mine, and Lindheim & Dewees. The main development has been done by the Marfa & Mariposa Mining Co. at whose mine ore has been found at a depth of 120 ft. This com-



WORLD'S PRODUCTION OF QUICKSILVER IN METRIC TONS.

pany operates a 10-ton Scott-Huttner furnace and in 1900 produced 750 flasks of quicksilver. The production of the other mines during the same period was: California, 200 flasks; Excelsior, 50 flasks; Del Rio (Lindheim & Dewees), 700

flasks, making a total of 1,700 flasks. The ores occur in Cretaceous and it is possible that the dikes of igneous rocks in the vicinity have had something to do with the origin of the cinnabar. The ores are distinguished by great richness in places, but the reported finding of large pockets of native quicksilver cannot be confirmed. The development of the district beyond a certain point may be retarded by the lack of fuel, as mesquit wood is about the sole dependence. However, asphalt and coal have been found about 8 miles distant and there is a possibility that oil may be discovered as the formation closely resembles the oil region around Corsicana. The district has not received the attention it merits owing to its remoteness from railways and the aridness of the region.

Mexico.—It is stated that steps are being taken to open up a large mine in Modesto County and that there are several promising properties in San Luis Obispo County.

QUICKSILVER PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria.	Canada.	Italy.	Mexico.	Russia.	Spain.	United States.	Total.
1895	535	2·5	199	213	434	1,506	1,179	4,069
1896	564	2·0	186	218	491	1,524	1,036	4,021
1897	532	0·3	192	294	616	1,728	965	4,327
1898	491	*Nil.*	173	353	362	1,691	1,058	4,128
1899	536	*Nil.*	205	324	360	1,357	993	3,775
1900	550	*Nil.*	220	*b* 335	*c* 340	1,111	967	3,523

(*a*) From official reports of the respective governments and direct reports of the producers to THE MINERAL INDUSTRY. The figures for Austria and Italy for 1898 are due to V. Spirek, that for Russia to the sole producer, and that for Spain to the *Revista Minera*. (*b*) Estimated imports. (*c*) Estimated.

GENERAL QUICKSILVER STATISTICS. (*a*)

	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. *b*)
Shipments from Spain to London	44,670	42,414	40,409	40,949	46,577	46,367	45,729	*c* 10,963
Shipments from Italy to London.	6,680	8,700	5,775	3,800	4,450	5,650	6,206	*c* 6,045
Total	51,350	51,114	46,184	44,799	51,027	52,017	55,935	17,008
Shipments from London	42,265	41,046	37,937	31,273	31,734	32,288	33,101	*c* 24,500
Maximum price of Spanish	£6 17s. 6d	£6 15s.	£7 7s. 6d.	£7 5s.	£7 7s. 6d	£7 15s.	£9 12s. 6d	£9 12s. 6d
Minimum price of Spanish	6 2s. 6d	5 10s.	6 7s. 6d.	6 8s. 6d	6 12s. 6d	7 0s.	7 15s.	£9 2s. 6d

(*a*) From W. Sargant & Co.'s Annual Metal Circular. (*b*) American, Russian and Italian flask, 76·5 lb. (34·7 kg.); Mexican flask, 75 lb. (34·03 kg.); Spanish flask, 76 lb. (34·5 kg.). (*c*) For the year ending Nov. 31, 1900.

Australasia.—In New South Wales cinnabar has been discovered on the Cudgegong River, near Rylstone. It also occurs at Bingara, Solferino, Yulgilbar and Cooma. Of these the Yulgilbar deposit is the most important, but its production has not yet been profitable. In the Kilkivan district, Queensland, a small amount of quicksilver was produced and the Jamieson Quicksilver Co., at Silver Creek, Victoria, is reported to have made a small output. In New Zealand, the Ohaeawai deposits in the Bay of Islands County are the most promising. The governments of New South Wales and New Zealand have offered a bonus to encourage the industry.

China.—The Anglo-French Quicksilver Mining Concessions, Ltd., operating at Kwei-yang, in Kwei-chau Province, was forced to discontinue work on account of the disturbed condition of the country. Considerable ore has been stacked

awaiting the arrival of furnaces of modern construction to treat it and the outlook of the industry is promising.

Italy.—(Vincente Spirek.)—The production of quicksilver in 1900 amounted to 220 metric tons, against 201 metric tons in 1899. The progress in the smelting of ores in the Monte Amiata district has been very rapid in those works using the Cermak-Spirek furnaces and condensers.* With their use it is possible to work ores containing as low as 0·3% Hg. The losses can be controlled very accurately by Eschka's testing method while the measurement of temperature and the "depression" of the gas conductors and condensers have fallen below 3%, an amount heretofore regarded as impossible. The introduction of the Cermak-Spirek method is to be made in the United States by an American company, and the furnaces are also to be used in the treatment of mixed ores from Algeria as well as for roasting zinc blende. The smelting works at Siele, Cornacchino, Abbadia, San Salvadore, Montebuono and Tuscany have been completely rebuilt according to this system, leaving the works at Cortevecchia the only exception. The average content of the Monte Amiata ores is from 0·3 to 0·8% Hg, an amount so small that without these furnaces and condensers the smelting would be an economic impossibility.

Russia.—The production of quicksilver in 1900 is estimated at 340 metric tons as against 360 metric tons in 1899.

Spain.—The Messrs. Rothschild have been granted a continuation for another 10 years of the concession in connection with the Almaden quicksilver mines in Spain. The output during 1900 was 1,111 metric tons, a decrease of 246 metric tons from the output in 1899.

* These have been described in detail in THE MINERAL INDUSTRY, Vol VII.

RARE ELEMENTS.

By Victor Lenher.

Especial attention has been drawn during the past year to the so-called new "radio active elements." From the interest they have created and from the investigations now being made on them, a plausible explanation will doubtless soon be made as to their peculiar properties. The strange power they possess of transferring their activity to other elements, giving rise to induced radioactivity, their continual association in nature with uranium and thorium only, the synthesis of radiferous barium salts by von Lengyel, the recent atomic weight determination of 174 for radium by Mme. Curie, all indicate the unsettled condition of the information that we now possess regarding them.

Debierne has studied more carefully the body in pitch blende residues apart from radium and polonium, which has been called actinium.

Moissan has prepared crystalline metallic calcium and has discovered some new and interesting bodies by the electric furnace.

Many new minerals have recently been discovered in Greenland, some of which contain a large percentage of the substances that are used in the manufacture of incandescent mantles.

The Colorado deposits of uranium and vanadium were worked during 1900, and the product shipped to Paris.

The International Atomic Weight Commission has inquired carefully as to whether the best general standard for comparison is H=1, or O=16.

Actinium.—Debierne* continued his researches on the new radioactive body in pitch blende, and showed that it is precipitated by nearly all the reagents for titanium. It belongs to the iron group and differs from radium and polonium.

The following methods of concentration are given as the best: (1) Precipitation of the boiling solution slightly acidified with hydrochloric acid, by an excess of sodium thiosulphate. The radioactive property is almost entirely in the precipitate. (2) By the action of hydrofluoric acid and potassium fluoride on the freshly precipitated hydrates suspended in water, the soluble portion only is active. This method serves for the separation of titanium from it. (3) Precipitation from the neutral nitrate solutions by hydrogen peroxide gives the radioactive substance in the precipitate. (4) Precipitation along with barium sulphate.

* *Comptes Rendus*, April 2, 1900.

Debierne systematically used the above methods and extracted the greater part of its content from pitch blende residues. The chemical reactions and its spectra seem to show that it consists chiefly of thorium. It, however, does not resemble thorium in all of its reactions. When a barium or bismuth salt is added to a solution of the new body, hydrogen sulphide or ammonia can eliminate the radioactive property, showing that it is neither radium nor polonium.

It ionizes gases, causes barium platinocyanide to fluoresce, produces photographic impressions and, in a magnetic field, its rays are deviated in a manner similar to those of radium. The new substance but feebly causes permanent induced radioactivity.

Austrium.—The orthite in which Linneman, in 1886, claimed to have discovered austrium has been again examined by Przibram, who concludes with Boisbandran that this supposed element is identical with gallium, and from a spectroscopic examination, reached the conclusion that it contains a new element yet to be isolated. It is provisionally named austrium, although it is different from the original austrium of Linneman.

Boron.—When one part of boron and five parts of silicon are heated for one minute by means of an alternating current of 100 amperes and 45 volts, and the cooled mass treated successively with a mixture of nitric and hydrofluoric acids, potassium hydrate, dilute nitric acid and hot water, the residue dried at 130°C., consists of two borides of silicon having the formulas SiB_3 and SiB_6, the latter forming about 80 to 90% of the mixture. SiB_6 is readily oxidized by boiling nitric acid and hydrofluoric, while SiB_3 is but slowly attacked by this reagent. The density of each is about 2·5. They conduct electricity, dissolve in fused silicon and are between the diamond and ruby in the scale of hardness.

Boult* patented a boron or silicon filament with pure boron or silicon as a base. An impalpable powder of boron is mixed with a carbonized, boronized or silicified solid or liquid compound which is decomposed by heat, leaving a small residue of carbon, boron or silicon. The mixture is forced through fine holes as filaments, which are calcined at a high temperature with exclusion of oxygen or nitrogen. The filaments are next "flashed" in boron hydride or ethyl boron. The filament itself may be formed by the flashing process by producing a deposit of boron, with or without a mixture of carbon on a fine platinum thread, the platinum being subsequently expelled by incandescence.†

Cæsium.—Eckardt and Graefe‡ have carefully studied the physical properties of metallic cæsium which was prepared by heating in an iron tube cæsium carbonate with metallic magnesium in an atmosphere of hydrogen. The following physical properties were observed: sp. gr. at 26°C. 1·886, solidifying point 26·37, specific heat 0·04817, atomic heat 6·406, heat of fusion 3·73 cal., electrical conductivity at 27°C. 3·63 (Ag=100), contraction on solidification 2·627% by volume, coefficient of expansion 0·0003948.

Calcium.—Moissan has prepared crystalline calcium by dissolving it in fused sodium. On cooling the calcium crystallizes. By treatment with absolute alcohol the sodium is removed and pure calcium appears as brilliant white

* English Patent No. 5,216, May 19, 1900. † *Journal of Society of Chemical Industry*, 19, 650, July 31, 1900.
‡ *Zeitschrift für Anorganische Chemie*, XXIII., 378, 1900.

hexagonal crystals. The metal can be directly obtained by heating to a dull red heat 240 g. of sodium with 600 g. of calcium iodide in a tight iron crucible for an hour. The sodium is broken into small pieces and added to the absolute alcohol. Electrolysis of the fused iodide at a red heat gives the crystalline metal. The negative electrode is of pure nickel, and the positive electrode is of graphite.

Cerium.—While the use of cerium in the Welsbach mantle makes a considerable demand for this rare earth, the minerals carrying the thoria, which constitutes 99% of the mantles, contain a larger excess of ceria than of thoria, consequently this element accumulates. Small amounts of the nitrate and oxalate are used in medicine.

The methods for the separation of the rare earths are becoming more perfect from year to year. Cerium can be readily separated from the other metals which accompany it by means of ammonium persulphate.* To this end Witt and Theel† boil a normal cerous salt with ammonium persulphate. A ceric salt is formed which decomposes at once into a basic ceric sulphate and free acid. If this free acid is neutralized as rapidly as it formed, the reaction becomes quantitative, the whole of cerium being precipitated as basic ceric sulphate while the other earths remain in solution. Inasmuch as the normal salts of the cerite earths have a faint acid reaction to litmus but do not react to Congo, the boiling liquid must be kept faintly acid to litmus but neutral to Congo paper. This is accomplished by means of a solution of sodium carbonate or finely powdered calcium carbonate. The cerium precipitate is easy to wash and the filtrate is free from cerium.

Chavastelon‡ effects a separation as follows: The neutral solution of the mixed salts are poured into a saturated solution of sodium sulphite. Nearly all of the thorium remains in solution while the other rare earths are precipitated. The addition of hydrogen peroxide to the hydrochloric acid solution of the sulphites precipitates the remainder of the thorium. The remaining oxides are precipitated by ammonia, suspended in a solution of sodium bicarbonate, and carbon dioxide passed through, when the cerium peroxide alone passes into solution and can be removed by filtration.

Knorre§ considers that the most delicate test for cerium is the addition of ammonium persulphate in a solution barely acid with sulphuric acid. The solution changes from colorless to yellow. The cerium can be determined by treatment with an excess of hydrogen peroxide and estimating the excess with permanganate.

A new mineral called florencite is described from Minas Geraes, Brazil. It contains 28% of the cerium earths. The crystals have a greasy to resinous luster, and show rhombohedral faces with a fairly good basal cleavage.

A large number of minerals from Greenland are described in the *Meddelelser om Grönland,* 24, 7. Britholite, a silicophosphate carries 60·64% of the cerium group. Chalcolamprite is a niobium mineral containing 59·93% Nb_2O_5, 5·71% ZrO_2 and 4·43% of cerium oxide. Parisite is a carbonate containing

* THE MINERAL INDUSTRY, Vol. VIII., 503.
† *Berichte*, 33, 1,315, May 14, 1900.
‡ *Comptes Rendus*, 130, 781, March 12, 1900.
§ *Berichte*, 33, 1.924, July 9, 1900.

28·14% ceria, 22·88% lanthanum and didymium oxides and 1·23% yttria. Cordylite is a carbonate containing 23·73% ceria, 25·67% lanthana and didymia with a trace of yttria and 0·30% of thoria. Ancylite is also a carbonate containing 22·22% ceria, 24·04% of lanthana and didymia and 0·20% thoria.

Meyer and Jacoby* have prepared a series of double nitrates of tetravalent cerium and thorium with ammonium, rubidium, cæsium, magnesium, zinc, nickel, cobalt, manganese, and strontium; they have also prepared the crystalline basic nitrate of cerium, $Ce(NO_3)$, $(OH)_3$.

Didymium.—By heating a mixture of the oxides of neo- and praseo-dymiums with sugar carbon in the electric furnace, Moissan obtained the respective carbides. They appear as hexagonal crystals, yellow in color and slightly darker than aluminum carbide. When slightly heated in fluorine, they burn, forming insoluble fluorides. Neodymium fluoride is white, while the praseo-salt is sulphur yellow. Heated in the other halogens they give the corresponding salts which are soluble in water. In oxygen at 400°C. they burn completely to oxides. They are more readily decomposed by boiling water than by cold water and give a complex mixture of solid, liquid and gaseous hydrocarbons, forming hydrated oxides. The mixtures are rich in acetylene and methane. Like cerium and lanthanum carbides, they correspond to the formula RC_2. Muthman and Stutzel obtained both didymium sulphides as well as cerium and lanthanum sulphides by heating the respective sulphates in hydrogen. Warm water and dilute acids give hydrogen sulphide. The sulphides burn readily in air when heated, and form a mixture of sulphide and oxide. Hydrochloric acid gas gives the anhydrous chlorides, which is the best method of preparation on a small scale.

Didymium oxides as well as those of thorium, cerium, lanthanum and samarium, when heated with magnesium unite directly with nitrogen. This reaction and the union of these reduced oxides with hydrogen has been shown by Matignon, while Moissan has shown that at 1,200°C. nitrogen reacts on didymium carbides with the formation of the corresponding nitrides.

Fluorine.—Continuing his work on this element, Moissan has prepared sulphur hexafluoride. It is a colorless, tasteless, odorless, incombustible gas which solidifies at 55°C. to a white crystalline mass. It liquefies and boils slightly above this temperature. It is slightly soluble in water and in most of its properties, it is similar to nitrogen. He has also prepared thionylfluoride, a body analogous to thionylchloride. De Silva and D'Aguiar report fluorine in the mineral waters of Spain and Portugal.

Gadolinium.—Benedicks† has reviewed the work on gadolinium. In 1880 Marignac discovered a new earth in samarskite. This earth was found to consist partly of the samarium oxide discovered by Boisbandran in 1879. In 1892 Bettendorf prepared what was considered pure gadolinium oxide. He fractionated it by means of potassium sulphate and obtained constant atomic weight results. Demarcay in 1896 proposed to fractionate the nitrate in nitric acid solution. Bettendorf prepared what was considered pure gadolinium oxide. He fractionated of the nitrate in concentrated nitric acid after the weaker bases have been re-

* *Berichte*, 33, 2,135. July 23, 1900. † *Zeitschrift für Anorganische Chemie*, XXII., 393, 1900.

moved; subsequently a partial precipitation by ammonia is made. Terbia and samaria earths are obtained in the first precipitates, nearly pure gadolinium in the last. Traces of didymia are removed by a further recrystallization of the nitrates. The nitric acid method is considered far less tedious than the potassium nitrate one.

The elementary character of gadolinium has been repeatedly doubted. Crookes by studying the phosphorescent spectrum, concluded that it was composed of three substances. Demarcay, from its spark spectrum, considered it might consist partly of another body whose oxide and salts would be colorless and distinguished from gadolinium by the greater solubility of the nitrate in concentrated nitric acid. Benedicks used a Salet tube with an induction coil which had a long secondary wire and obtained a beautiful spectrum consisting of bands and bright lines.

Gd_2O_3 is the only oxide; it is a white powder with a scarcely visible yellow tint, probably due to terbium. It dissolves in acid readily, absorbs water and carbon dioxide from the air, and is not reduced by heating in hydrogen. A large number of very well defined salts were prepared. With a few exceptions they are colorless, show no absorption spectrum and have a sweet, astringent taste. In general they resemble yttrium salts.

A mean atomic weight of 156·38 was obtained for gadolinium by conversion of the oxide to sulphate. Berthelot obtained 156·33 and Cleve 155. Benedicks considers that the earth more closely resembles the yttrium than the cerium metals and assigns it to the eighth horizontal row in the periodic system.

Demarcay has isolated a decided quantity of the double nitrate of magnesium and gadolinium. He considers 155 as too high an atomic weight.

Iridium.—The platinum and iridium residues have been studied by Leidie* and a general method of separation has been worked out. The residues are successively roasted in the air, reduced in hydrogen and extracted with dilute hydrochloric acid. This mixture is heated with sodium chloride in chlorine to redness. The products are treated with water and the insoluble residue again acted on. The solution in 20 parts of water is allowed to stand 24 hours, which removes most of the silver, lead and bismuth as insoluble chlorides. The solution is filtered, heated to about boiling and gradually added to a slight excess of sodium nitrate. The iron is precipitated as sesquioxide and the gold as metallic. Sodium carbonate is then added to precipitate the lead, copper and bismuth. The platinum, palladium, iridium, rhodium, and ruthenium remain in solution as double nitrites with sodium, while the osmium is in the form of chlorosmite.

In order to separate the platinum metals from each other the solution to which soda is added is treated with chlorine, first in the cold then at 50 to 60°C. Per-osmic and per-ruthenic anhydrides distil and are collected in alcohol and water which reduce them to osmium and ruthenium. These two metals are separated by the method of Deville and Debray. The alkaline liquid is then saturated with hydrochloride acid, a fresh quantity of sodium nitrite is added to retransform the chlorides into nitrites and ammonium chloride is added. The iridium and rhodium are precipitated as double nitrites of ammonium which are

* *Comptes Rendus*, 131, 888, Nov. 26, 1900.

insoluble in the solution of ammonium chloride containing sodium chloride. These are treated with hot hydrochloric acid, evaporated and later dissolved in water, from this ammonium chloride precipitates the iridium, while the chloride of rhodium remains in solution. The ammonium-iridium chloride is heated with its weight of sodium chloride to 450°C. and gives the sodium salt, which is soluble in water and frees it from the rhodium. The sodium salt is again transformed into ammonium salt which gives iridium when heated to dull redness in hydrogen. The rhodium ammonium chloride in the filtrate from the iridium is transformed into the double sodium nitrite, then into the ammonium salt, and this salt by hydrochloric acid into rhodium ammonium sesquichloride. The latter heated to redness in hydrogen gives rhodium. The filtrate from the iridium and rhodium contains platinum and palladium with possibly only traces of iridium. It is evaporated to dryness with concentrated hydrochloric acid to obtain the chlorides and is then ignited. The residue is treated with water to remove the alkaline salts, and then dissolved in aqua regia, the excess of which is removed by evaporation to dryness. The residue is taken up in water and precipitated by ammonium chloride. The palladium and iridium are held in solution by a reducing gas, preferably nitrogen dioxide, which is subsequently removed by a current of carbon dioxide. The ammonium chloroplatinate is recrystallized from boiling water and by reduction in hydrogen at redness gives platinum. The mother liquors treated with mercury cyanide give palladium cyanide. This salt is decomposed by heat. The palladium is dissolved in nitric acid, the nitrate transformed into ammonium chloropalladite. This is reduced at a red heat and when cooled in carbonic acid, gives palladium.

Krypton.—Ladenburg and Kruegel* have still further investigated this new gas; 850 liters of liquid air fractionally distilled yielded 32 c.c. of krypton or 0·083 g. They obtained a molecular weight of 59·01 instead of 58·81 and 58·67, which were obtained previously. The gas is probably free from nitrogen and argon, or contains only traces. It may possibly contain xenon but in this case the density of krypton would be too high.

Osmium.—Imray† has patented the use of osmium filaments in incandescent lights. Since osmium filaments have a large capacity for occluding gases and are very sensitive to exceedingly small quantities of oxidizing gases as CO_2, etc., they are first heated to a white heat in vacuo. The oxidation of the osmium filaments is prevented when it contains a more readily nonvolatile body, as carbon, zirconium, thorium, niobium, silicon, etc. The knowledge of this element has been further extended by the work of Rosenheim, who has studied the complex sulphites, and Wintrebert, who has obtained the osmyl oxalates.

Palladium.—Loiseleur has prepared pallado-oxalic acid, and the salts of silver, sodium, and barium. This preparation is the only complex acid of palladium discovered up to the present time. The free acid appears in well formed crystals. The use of palladium in a toning bath for photographic work is given in the *Chemiker Zeitung,* Rep., 24, 216, 1900.

Radium.—Continuing their work on the radioactive bodies M. and Mme. Curie show that radium rays are deviated in a magnetic field in the same way as

* *Chemical News*, 82, 209, Nov. 2, 1900. † English Patent No. 10, 241, May 15, 1899.

cathode rays, but to a less degree. Mme. Curie in earlier atomic weight determinations obtained 146; more recent work from a purer chloride gave 174·1 and 173·6. She thinks the atomic weight is much higher than 174, while Demarcay thinks that the specimen examined contains rather more radium than barium. Crookes* has followed the work of Becquerel on the uranium compounds, which are known to possess the property of radioactivity, that is, the power to affect a sensitive photographic plate through bodies usually considered opaque. Crookes investigated barite and witherite from various sources but found they were without action on a photographic plate in 48 hours. On examining a large number of minerals he found that only those are radioactive which contain thorium or uranium. Pitch blende is the most active of all, but specimens from different sources differ greatly in action.

Further,† by an extraction of uranium nitrate with ether, he found its evaporation gave an intensely inactive product, while the aqueous layer showed the active substance. The latter was fractionated and a highly active uranium nitrate obtained. Another portion of active uranium nitrate was treated with excess of ammonium carbonate. The first precipitate almost entirely dissolved, but a light brown portion, insoluble in excess contained almost all of the radioactive constituent and dissolved easily in dilute sulphuric acid while radium forms an insoluble sulphate. Similar experiments indicate that a radioactive substance can be separated from thorium.

Doubtless one of the most curious properties that these strange substances possess is their power to transfer their radioactivity to other bodies. Debierne finds that when a highly radioactive salt of actinium is added to barium chloride solution, the latter becomes radioactive, more so if the barium is precipitated as sulphate. The actinium can be removed by ammonia. This induced activity increases with the length of contact. He thus prepares artificial active barium chloride whose activity is several hundred times greater than that of ordinary uranium. The rays emitted appear similar, they ionize gases, provoke phosphorescence of barium-platino-cyanide, and act on photographic plates. It can be fractionated similarly to radiferous barium chloride. It does not, however, give the spectrum of radium and its activity diminishes in time.

Rutherford assumes that thorium compounds emit a certain radioactive material which carries an electric charge; a current of air diminishes the radioactivity and also the induction near the substance.

From the experiments of Bela von Lengyel‡ and others, including the above mentioned, great doubt is cast on the elementary character of radium. He heated barium and uranium nitrates in the electric arc, and by precipitation as sulphate actually prepared first, radioactive barium sulphate, and from this an active carbonate and chloride. Evidence certainly is not at hand to show the elementary character of any of these radioactive bodies.

Rhodium.—In verifying the reproduction of potassium and rhodium double cyanide by the dry and wet method, Leidie found it to crystallize in slightly yellow monoclinic prisms that are anhydrous and easily soluble in water.

* *Chemical News*, 81, 253, June 1, 1900.

† *Proceedings of the Royal Society*, 66, 409, 1900.

‡ *Chemical News*, 82, 25, July 20, 1900.

According to Dr. Roessler,* of the Gold and Silver Refinery of Frankfort-on-the-Main, rhodium appears to have been confused with iridium in some cases. If 5 mg. of rhodium are fused with 1 g. of silver melted in lead, the regulus obtained by cupellation is dim gray. When it is dissolved in nitric acid, the gray film disintegrates into fine glittering scales which float in the solution. These scales are hexagonal crystals of pure rhodium. When more rhodium is added, it appears in the amorphous state, hence rhodium does not form an alloy with silver, and is not soluble in silver, but in lead. Iridium acts in a similar manner. In the case of silver and platinum, an alloy is formed and when it contains only a small portion of platinum on treatment with nitric acid, some of the platinum which is itself insoluble in nitric acid, passes into solution with the excess of silver. The alloy of rhodium and gold resembles platinum silver. It dissolves in aqua regia with a color darker than that which gold alone gives.

The properties of rhodium are evidently influenced by a large excess of gold. If more than 5% Rh is forced into the gold, which requires long continued fusion, the excess of rhodium is afterward found in beautiful star-shaped or feathery needles, easily distinguished from gold by their gray color. Gold and rhodium seem to form a real alloy but it has not been isolated so far. To investigate the question further, Roessler prepared alloys of rhodium with bismuth, tin and antimony. The metals have to be heated above their melting points for some time. Bismuth takes up 5% maximum of rhodium. When the excess of bismuth is extracted with cold dilute nitric acid, crystals of $RhBi_4$ remain, which are themselves soluble in boiling nitric acid. The same crystals can be prepared by fusing together the respective proportions of the two metals corresponding to that formula, and those crystals are entirely soluble in hot nitric acid; no bismuth can then be extracted with cold acid. Any excess of rhodium is afterward found in the crystallized or in the amorphous state; the amorphous metal had evidently not been taken up by the fused mass.

Samarium.—It has been shown by Demarcay that samarium can be obtained in a state of comparative purity by the crystallization of the double magnesium nitrate. The earth is white, slightly tinged with a rose pink; the salts are pale rose and the nitrate solution shows absorption bands. The nitrate forms thick orange red plates, while the double magnesium nitrate forms large yellow rhombohedral crystals.

Selenium.—A careful study of the allotropic forms and the physical properties of selenium has been made by Saunders,† who considers three forms: (1) liquid including the vitreous, amorphous, and soluble varieties, (2) red crystalline, (3) black crystalline or metallic. The latter is the most stable, the red crystalline being intermediate. The vitreous changes to the metallic on heating, rapidly above 60°C. The red crystalline is formed from certain solvents. In presence of various organic liquids, amorphous selenium is converted more or less rapidly into one of the other forms. The red crystals have an unstable melting point below 217°C, which is the melting point of the black crystalline variety. The sp. gr. of the amorphous is 4·26, of the vitreous 4·28, of the red crystals 4·47, and of the metallic 4·80.

* *Engineering* (London), Nov. 30, 1900. † *Journal of Physical Chemistry*, 4, 423, June, 1900.

Fonzes-Diacon prepared a number of metallic selenides by (1) reduction of selenates at a very high temperature with hydrogen, (2) by reduction of the selenates with carbon in the electric furnace, (3) by the action of hydrogen selenide on the salts of the metals, (4) by reduction of selenates with metallic aluminum. A series of iron, nickel, cobalt, and manganese selenides were prepared and a red chloroselenide corresponding to the red chlorosulphide of lead.

The use of selenium as a new reagent for the alkaloids has been demonstrated by Mecke;* characteristic colors are given. Schlogdenhauffen and Pagel† have detected selenium in commercial sulphuric acid by means of codein. Only a few drops of the acid are necessary. An intense green color first appears, then a blue color. If five or six drops of sulphuric acid are poured on a fragment of codein and a green color appears in the cold which changes to a greenish blue on the water bath, it is certain that selenium is present. The reaction is very sensitive.

Silicon.—New barium, strontium, and calcium silicides have been prepared by Jacobs‡ of New York. They are made by fusion of silica in the form of ground quartz or sand, with an alkaline earth carbonate or oxide and sufficient carbon to affect reduction. The mixture is heated in the electric furnace, or corresponding silicates are heated with carbon. Strontium and calcium silicides are white or blue-white substances with a metallic appearance and resemble aluminum silicide or silicon. They show a crystalline fracture similar to that of zinc. They slowly oxidize in the air and are decomposed by water with evolution of hydrogen. The calcium compound dissolves slowly in cold water and more readily in warm. The barium compound rapidly decomposes both cold and warm water while the strontium compound is intermediate. When calcium silicide is treated with dilute acids it gives a new hydride which is named silico-acetylene, which is a yellow crystalline compound, stable at ordinary temperatures. A 20% solution of caustic potash or soda gives hydrogen. Heated in the air, it rapidly oxidizes, while heated in a closed tube, amorphous silicon and free hydrogen are formed. The other silicides when treated with acids do not give this compound. The silicides can be produced at low cost where electric power is cheap, and as they are powerful reducing agents, it is hoped that they will find large use in dye works. Experiments on molten steel have shown that the requisite amount of barium or calcium silicide completely removes phosphorus and sulphur as well as all oxygen present.

The preparation of crystalline silicon in the electric furnace has been patented by Scheid.§ The following mixtures are used: (1) Carborundum and silica. (2) Carborundum with an acid, neutral or basic silicate of the alkaline earths or earths. (3) Carborundum together with silica and the above silicates. (4) Carbon with silica in proportions less than to make carborundum. (5) Carbon and silicates as above. (6) Carbon and silica with silicates as above. The silicon appears as compact nodules or lumps which when prepared in a large furnace are cast in the form of amorphous pigs. Crystalline iron silicide hav-

* *Zeitschrift für Analytische Chem.*, 39, 468, 1900. † *Journal Pharm. et de Chim.*, Series 6, Vol. XI., No. 6, 1900.
‡ *Chemical News*, 82, 149, Sept. 28, 1900.
§ *Journal of the Society of Chemical Industry*, 19, 825, Sept. 29, 1900.

ing the composition Fe_2Si has been prepared by Lebeau by fusing copper silicide with an excess of iron in a wind furnace. The compound is found in commercial ferrosilicon, containing 10 to 20% Si, and imparts to it its properties.

Hempel and von Haasy* prepared some new interesting silicon derivatives. Silicon fluoride is reduced by heated sodium. An aluminum alloy containing 16% Si is formed and the excess of aluminum dissolved out by hydrochloric acid. An active form of the element is obtained. From a 22·5% alloy the silicon separated is very inert. By melting amorphous silicon with three times its weight of sulphur and throwing the mass into a red hot crucible SiS_2 is obtained. The product, purified by distillation under reduced pressure, appears as beautiful long white needles. When this sulphide is fused with sodium sulphide, Na_2SiS_3 is formed as a brown black mass. This substance evolves hydrogen sulphide with water giving a solution which evolves no more hydrogen sulphide when treated with acids. Chlorine gives sulphur chloride and silicon chloride with the evolution of heat. This reaction is applied to the detection of thiosilicides in some complex silicates, and ultramarine by this way is found to contain 0·174% SiS_2, blast furnace slags 0·009 to 0·104% SiS_2, Vesuvian lava 0·007% SiS_2. They suggest that the presence of sulphur in many springs may be due to the decomposition of thiosilicides.

Tellurium.—Regarding the telluride ores of Cripple Creek and Kalgoorlie, Rickard† says of the common Colorado and West Australia tellurides: Sylvanite, although it does not carry the largest portion of the gold obtained from the Cripple Creek ores, is the telluride most frequently seen in specimens from that district. It is uncommon at Kalgoorlie, but is particularly characteristic of the ores of Boulder County, Colo., especially around Salina. It occurs in brilliant white twinned crystals, often distributed over the faces of pieces of rock so as to look like arabic writing, hence the name, "graphic tellurium." The mineral contains about 60% Te, 16% Au, 14% Ag.

Krennerite is a telluride occurring as prismatic brilliant vertically striated crystals in the ores of the Moon-Anchor and other mines on Gold Hill, Cripple Creek. The color of krennerite is like that of sylvanite, but it frequently displays a slight tinge of brassy yellow. It is the most beautiful of all the tellurides and contains about 59% Te, 36% Au, 4% Ag. Black tellurium or "coloradoite" is mercury telluride, first detected in the Mountain Lion mines at Magnolia, Colo., is also found at the Kalgurli mine at Kalgoorlie. It contains 38·5% Te, and 61·5% Hg. It is iron black with a subconchoidal fracture and the rich greasy luster which is characteristic of several other tellurides, particularly calaverite. There is a variety of coloradoite named kalgoorlite that contains about 11% Hg, 21% Au, 31% Ag, and 37% Te. It is regarded as a mixture of petzite, contains 40·5% Ag, 24·6% Au, 34·6% Te, with traces of mercury. Petzite is the characteristic mineral of the Golden Fleece mine, Lake County, Colo., but crystalline specimens are not obtained.

The two minerals fluorite and roscoelite seem to be specially associated with tellurides, and characteristic of tellurium ores. Fluorite is calcium fluoride, frequently of an amethyst to purple color. Roscoelite is a brownish green

* *Zeitschrift für Anorganische Chemie*, 23, 32, 1900. † *Engineering and Mining Journal*, Nov. 17, 1900.

micaceous mineral belonging to the hydromica group and carries from 20 to 28% V_2O_5.

Higgins has reported melonite in quartz and calcite at Worturpa, South Australia. It appears in thin lamella with brilliant metallic luster. The cleavage planes are silver white to red brown. Hardness is 1·5, sp. gr. is 7·6. It contains 71·5 to 74·5% Te, and 21·3 to 23% Ni. This mineral has previously been known only in California, and a recent analysis of a specimen made by Hillebrand from Melones mine, in the Mother lode, shows 80·7% Te, and 18·3% N.

Rickard has observed that in the roasting of tellurides, the TeO_2 produced readily unites with ferric oxide and forms iron tellurite which is apt to coat the particles of the native gold disseminated through the ore and render it difficult to amalgamate them. At the Great Boulder Main reef this difficulty is largely overcome by grinding the roasted ores.

Head and Ward of London remove tellurium from refractory ores by digesting them with a solution of potash.

Hydrogen telluride has been obtained in a pure condition by Ernyei, who electrolyzed 50% sulphuric acid, using a tellurium cathode, and a 220 volt circuit. The apparatus was cooled to —15 to —20°C. and the evolved gas was immediately dried thoroughly. It was condensed by means of liquid carbon dioxide when it appeared as a greenish yellow liquid. It boils slightly above 0°C., dissolves readily in water, but on contact with air, the solution decomposes. The solutions of the alkaline tellurides likewise decompose readily. From a vapor density determination its molecular weight is 130·2.

Thorium.—Studying the effect of varying the mixtures of thorium and cerium in regard to the luminosity of mantles in the Wehnelt arc, Thiele has shown that it is not changed by increasing the amount of ceria up to 5% but with larger amounts, the luminosity decreases owing to the increased resistance. In the Wehnelt arc, as in the Bunsen flame, the luminosity is at a maximum in the mixtures containing 1 to 2% of ceria. Muthman and Baur* have observed that mantles made from commercial thorium nitrate frequently have a strange variation in their illuminating power, aside from the well-known influence of phosphoric acid, the alkalies, iron oxide, etc. They examined samples of commercial thorium nitrate by the cathode luminescence method and found that they regularly contained impurities of other rare earths. The method of fractionation by potassium chromate gave end fractions of 0·3% of gadolimium, neo- and praseo-dymium. They made photometric tests with mantles of pure thoria, obtained in this manner and showed that very small impurities, consisting of rare earths, have a very detrimental influence on the luminosity of the thoria-ceria mixture. This accounts for the variation in illuminating power, observed in commercial specimens. The usual impurities in cerium nitrate have no effect on the illuminating power, as they form so small a proportion of the mantle.

O. A. Derby,† investigating the monazite sands of Prado, Brazil, states that a single grain of monazite can be rapidly and securely identified by moistening it with sulphuric acid on a slip of glass and driving off the acid over a spirit

* *Berichte*, 33, 2,028, July 23, 1900. † *American Journal of Science*, September, 1900.

lamp. The cerium crystallizes, in double ball-shaped clusters of radiating needles or minute isolated crystals shaped like cucumber seeds. This is better shown by the addition of a drop of water, allowing the crystallization to take place in a desiccator. Another drop of water with a little ammonium molybdate gives on evaporation a satisfactory test for phosphoric acid. The other elements are easily detected in various ways.

The Franklin Institute of Philadelphia has recently awarded the Elliott Cresson medal to Dr. Carl Auer von Welsbach, of Vienna, in consideration of the enormous advance in the art of artificial lighting, and the Edward Longstreth Medal of Merit was awarded to Welsbach Light Co., of Gloucester, N. Y., in view of the many details wrought out by them. The report was made through its Committee on Science and the Arts referred to by the Bureau of Awards of the National Export Exposition. The report* treats of the production of artificial lighting by means other than the use of the flame burning carbonaceous material in the ordinary candle, lamp, or gas burner, from an historical standpoint, and gives some interesting details of the more modern lights.

It is probable that Lieut. Thomas Drummond was one of the earliest discoverers of the fact that heated oxides of certain elements incandesce. While in the English government service in 1826 he made the discovery that a piece of lime, or better a piece of magnesium oxide, or, most refractory of all, a piece of zirconium oxide when heated in an oxyhydrogen flame incandesced, giving off an intensely bright white light. In 1868, Le Roux, professor at the École Polytechnique, Paris, discovered that a brilliant incandescent light might be produced from a rod of lime or magnesia, by heating it until an electric current passes, this afterward maintaining the light. In 1879, Jablochkoff patented the use of kaolin, making it incandesce by passing an electric current through it. He noticed that the kaolin he had passed between the carbons of his arc lamp assisted the illumination.

Jackson, in 1881, invented a lamp of platinum, iridium, or other metals non-oxidizable at high temperatures. He heated in a flame a small section of wires and observed that the finer the wires the more intense the light produced, and from this began the mantle light. In 1881, Lungren, of New York, patented an improvement which consisted of passing a non-luminous gas flame through a clay heater or similar material highly heated by jets of the non-luminous gas and forcing atmospheric air through the heater, which caused it to mingle with the non-luminous gas issuing in one or more jet flames against lime, magnesia, zircona, or similar material producing incandescence. Later patents of Lungren subsequently appeared for filaments to be used similarly to the Welsbach mantle. Lungren's invention was never made commercial. In 1882, Clamond, a Frenchman, made use of magnesia threads heated to incandescence in a mixture of gas and air. Fahnehjelm, in 1885, patented a light which consisted substantially of a series of rods of calcined magnesia, resembling the teeth of a comb, held in a suitable flame and suspended in a non-luminous flame of gas. The next year, Galopin and Evans produced a lamp burning hydrocarbon vapor mixed with air to produce a heating flame directed downward into a woven platinum mantle

* *Science*, Dec. 21, 1900.

thus made incandescent. It was about the same time, or even earlier, that von Welsbach announced the invention of the lamp in which lanthanum, yttrium, zirconium, and similar oxides in a finely divided condition were rendered incandescent by heating to a high temperature. The source of light was a light network of cotton impregnated with a solution of the salts of the combined nitrates, oxides, or bromides. After being saturated with these, upon exposure to heat, the supporting cotton network was burned out, the salts converted into the oxides and a skeleton hood or cap thus prepared which became incandescent when a heating flame was applied to it. Welsbach found that this mantle could resist the action of atmosphere fit to breathe for an indefinite time and was not changed by exposure, two factors that favored its effectiveness for a long time.

During the following five years or longer, von Welsbach made elaborate investigations for perfecting the many details required to make the lamp practical. It was strengthened, processes for extracting the salts from the ores were invented, etc. In his patent of August 20, 1889, No. 409,531, he explains that the illuminating power is greatly increased by adding thorium oxide; that lanthanum oxide without sufficient thorium oxide crumbles when incandescent, making the mantle flexible. He later found that thorium oxide by the addition of a small amount of uranium or cerium oxide has very high illuminating power and produces a vivid and nearly white incandescent light, in spite of the fact that thorium oxide alone radiates but little light which is yellow in color, and that uranium oxide alone radiates little light and it is yellowish red. Still later he discovered that the illuminating power of lanthanum, cerium, yttrium, zirconium, and other refractory earths are greatly increased by the addition of thoria, that ceria gives not only a desirable yellow light but greatly increases the life of the mantle by causing it to hold its shape better, which makes it stronger and more durable in every way.

Mention should be made of the Nernst lamp in which a magnesia rod is rendered incandescent by the electric current after a preliminary heating. In his latest work, Nernst gives up the magnesia and uses a mixture of oxides similar to those used in the Welsbach mantles, zircona, thoria, ceria, erbia, etc.

A brief description of the lamp and mantle made for use with illuminating gas by the Welsbach Light Co., of Gloucester, N. Y., will give the best idea of the present methods and will bring out as well some important points in reference to light giving power, durability and economy of the mantle as put on the American market.

The Welsbach "J" mantles (standard until very recently) were made as follows: A six-cord thread was woven on a knitting machine forming a tube of knitted fabric of rather open mesh. This web has the grease and dirt thoroughly washed out of it, and when dried, is cut into lengths double that required for a single mantle. It is then saturated in the fluid* produced from the monazite sand, wrung out, stretched over spools and dried. The double lengths are next cut in two, the tops of each piece doubled back and served with a platinum wire which draws the top in and provides a support from the wire holder for the

* With a solution of 300 g. of thorium nitrate and 4 g. cerium nitrate in a liter of distilled water, 275 to 280 mantles can be impregnated.—V. LENHER

finished mantle. After stretching the mantle over a form, smoothing it down and fastening the platinum wire to the wire mantle holder, the mantle is burned out by touching a Bunsen burner to the top. The cotton burns off slowly, leaving a skeleton mantle of unconsumed metallic oxides which preserves the exact shape and detail of every cotton fiber. The soft oxides are then hardened by a Bunsen flame. During burning out and hardening, considerable shrinking takes place. The process is finished by an immersion in crystalline, to prepare it for transportation, after which it is trimmed and packed. This mantle gives 75 initial candle power under the gas pressure of Philadelphia illuminating gas. Its life is not much below 1,000 hours. The candle power drops quite rapidly at first and more gradually afterward falling to one-half the initial candle power before the mantle breaks. The mantle first made in America in 1888, gave 35 to 40 candle power. The new mantle known as the "Yusea" has a much more open mesh than the "J," and is made by lace-making machinery. It is supposed to be much stronger than the older mantle and gives about 100 initial candle power.

The defects pointed out in the mantle are that it is extremely fragile and cannot be made to stand where it is subject to continued vibration: the quality of the light is such as to require the adjectives cold, ghastly, harsh, in describing it; and often a greenish tint in the light is evident. The candle power drops badly early in the life of a mantle, which is especially subject to this trouble where much dust occurs in the air; the oxides seem to volatilize slowly from the mantle, as evidenced by the shrinking in size of the strands of the mantle and the white deposit on the chimney, for platinum melts easily in the part of the flame where the mantles hang. If the mantle breaks, a hole being thus produced in it, the hot flame strikes out through this, breaking first the chimney, and as a result the mantle itself.

Titanium.—Methods of extracting titanium from bauxite residues have been recently studied and a number of patents taken out in England. The titanium is extracted either by boiling with strong sulphuric acid or fusion with sodium acid sulphate. Titanic acid is subsequently precipitated by boiling.

The preparation of titanium and its alloys by A. J. Rossi has been highly successful on a manufacturing scale, and reference should be made to his special article on this subject elsewhere in this volume.

In titaniferous iron ores, Baskerville* estimates titanium by fusing 0·5 g. ore with 0·5 g. sodium fluoride and 5 g. potassium acid sulphate for fifteen minutes. The fused mass is dissolved in boiling water containing 3 c.c. nitric acid, ammonia added and the excess expelled by boiling. The well washed precipitate is dissolved in dilute hydrochloric acid and dilute ammonia is added until a slight permanent precipitate is obtained, which is redissolved in a drop or two of dilute hydrochloric acid (1 to 100). The titanium is now precipitated by saturating with sulphur dioxide and boiling for a few minutes. It is weighed as TiO_2. In case many determinations are to be made, Baskerville recommends the colorimetric process with hydrogen peroxide.

Uranium.—The development of uranium mining in Colorado is progressing

* *Journal of the Society of Chemical Industry*, 19, 419, May 31, 1900.

and considerable ore has been shipped to France. The ore is valued at about $500 per ton.

On account of the shutting down of the Bohemian uranium mines a good market has been created for the American mineral. The deposits of Russel Gulch, Gilpin County, Colo., discovered by Richard Pearce in the early seventies, were carefully worked by Poulot and Voillequé, but neither the Wood mine, the German, nor the Kirk, although containing rich pitch blende, gave good financial results, the ore being scattered too widely through the hard granite rock.

The new mineral carnotite is found in San Miguel, Montrose, and Dolores counties, Colo., a few veins being traced into Utah, near Moab, but they amount to little. The uranium district now comprises about 100 sq. miles where the mineral impregnates the upper part of the sandstone hills. The sandstone contains disseminated deposits and carries from 1 to 3% U_3O_8. Specimens are obtained running 25 to 30% U_3O_8, but the main ore runs lower, averaging 2 to 3%.

Near Placerville the deposits run 0·3% U_3O_8, and are too low to be valuable.

The deposits are worked in four districts: La Sal Creek, Roc Creek, Hydraulic, McIntyre Cañon.

The La Sal Creek ore contains molybdenum; Roc Creek, copper; Hydraulic, lime, and Placerville, roscoelite.

Early in the history of the deposits, a few tons of the ore were shipped to Europe, but it has now been found practical to extract the uranium on the spot. Two large plants with every mechanical conveyance will soon be completed by Poulot and Voillequé in the McIntyre Cañon and at Hydraulic, with the object to treat their own ores and to do custom work as well. The treatment consists of a lixiviation of the sandstone and separation of the impurities from the solution. None of the ore is rich enough to bear the freight charge of $50 per ton to New York.

The reduction of oxide of uranium by metallic aluminum in the presence of liquid air has been accomplished by Stavenhagen. A mixture of 30 g. of the oxide with aluminum is treated with 20 c.c. liquid air and ignited. A violent reaction takes place and a regulus of metallic uranium is obtained.

In continuing his work on the oxides of uranium, Aloy* obtained UO_2 as black microscopic crystals by heating uranic hydroxide in hydrogen. It is slowly converted to the green oxide by heating to redness. The violet hydrate of U_3O_8 which Ebelman prepared by exposing the oxalate to sunlight is more readily obtained from an alcoholic solution of the acetate or from a mixture of an aqueous solution of the acetate with ether. The violet hydrate is readily oxidized to uranic hydrate by exposure to air and when boiled with water, orthorhombic crystals of UO_3H_2O are formed, which are stable at 100°C.

Vanadium.—The Colorado deposits of vanadium† have been examined and the ore analyzed by Hillebrand and Ransome.‡ The deposits are found near Placerville in San Miguel County and in the western part of Montrose County. In the Placerville deposits, the roscoelite occurs in the La Plata sandstones.

* *Bulletin Société Chimique de Paris*, 3. 368, May 20, 1900. † THE MINERAL INDUSTRY, Vol. VIII., pp. 505-506.
‡ *American Journal of Science*, 120, August, 1900.

The carnotite is not so abundant in this deposit and occurs as minute yellow specks.

In the deposits in western Montrose County, carnotite occurs as irregular pockets in the sandstone. The carnotite analysis shows 59 to 61·5% UO_3 and 20 to 21% V_2O_5. K_2O runs from 4·3% to 8·4%. The vanadiferous silicate in the carnotite ore carries about 1% V_2O_3. They summarize that the body called carnotite is probably a mixture of minerals of which analysis fails to reveal the exact nature. Instead of being pure uranyl-potassium vanadate, it is to a large extent made up of calcium and barium compounds. Intimately mixed with it and entirely obscured by it is an amorphous substance, a silicate or mixture of silicates, containing vanadium in the trivalent state, probably replacing aluminum. The deposits of carnotite, though distributed over wide area of country, are, for the most part, if not entirely, very superficial in character and of recent origin.

The green coloring and cementing material of certain sandstones near Placerville, Colo., is a crypto crystalline alumino-vanadio-potassium silicate, resembling roscoelite, but with the percentages of Al_2O_3 and V_2O_3 reversed. It constitutes over a quarter of the sandstones at times, and contains nearly 13% of V_2O_3, the latter amounting in the maximum case observed to 3·5% of the sandstone. As yet these highly vanadiferous sandstones have been found only at Placerville, where it is intended to work them for vanadium. Carnotite is associated with them in only trifling amount.

Recent determinations of vanadium in the Colorado deposits by Poulot show that the brown sandstone carries 5·65% V_2O_5, the light green ore 2·60% V_2O_5, and the yellow ore 1·82% V_2O_5. The sandstone carrying 2% of the potassium uranovanadate runs about 0·4% V_2O_5. The ores might be treated with success provided a good price and a market for the vanadic acid were obtained.

While vanadium has until recently been considered a rare element, we now know it to be widely distributed. It is reported in the ashes of plants, and in the ashes of coals. The Mendoza coal of the Argentine Republic contains about 10% alkaline vanadate. Nearly all the New South Wales coals contain vanadium, the highest amount being 0·12% V_2O_5, although they usually contain less. The clays and shales around Sydney contain small quantities of vanadium, which appears frequently in the weathering of bricks as a yellow green and red stain. A large number of iron ores and bauxites are reported to contain vanadium.

The use of vanadium in dyeing has decreased on account of the substitution of cheaper substances, and on account of the fact that unless great care is taken vanadium is apt to injure the fiber. The Alloys Syndicate of London has manufactured ferrovanadium and has offered it at a reasonable price for use in alloying with steel.

Vanadic acid in aniline black is heated with aniline chloride, with reduction to V_2O_5. The latter oxide can again become active by oxidization with potassium chloride. Applied to pottery and fired at a high red heat, the oxides give a fine gold color with a greenish tinge. Since the finding of vanadium minerals in Colorado, vanadic acid has been offered for sale as low as $1 per lb. Should

vanadium come to the front in metallurgy a good supply could be derived from the Colorado deposits.

J. Baxeres* has lately determined the influence which vanadium exercises upon iron. In an alloy containing only 0·5% V the tensile strength is increased from 39 kg. to 61 kg. per sq. mm. with 10% elongation. If 0·5 kg. V per ton be added to a bath of iron the tensile strength of the iron increases from 7·5 to 13 tons per sq. in., this being the mean of 25 experiments. The addition of even a very small amount of vanadium increases essentially the malleability and hardness of steel after tempering. In this way sheet steel and steel armor may be prepared which will have a very hard surface but soft interior. Vanadium steel is particularly suited for wheel tires. Ferrovanadium containing 29·1% V prepared according to the method of Baxeres in London is being sold to Krupp, Armstrong, Whitworth and others, while the English Admiralty and War Department are experimenting with the material.

A variety of vanadium alloys have been made by using aluminum first. A cast bar with 1% V had a tensile strength of 11 tons, an elongation of 7% aluminum bronze, with 8 parts Al, 1 part V, gave 45 tons tensile strength and 12·5% elongation. Ordinary malleable iron of about 24·5 tons tenacity and 19% elongation was changed by the addition of 0·5% vanadium to 39 tons and 12% elongation in the forged bar, and 33·7 tons and 32% elongation annealed. This has called attention to the remarkable malleability and ductibility of the alloy. A mild steel of 30 tons tenacity and 17% elongation, with 1% vanadium gave 61 tons tenacity and 14% elongation, and when annealed 45 tons and 20%. Although very soft when annealed, these alloys become very hard by tempering.†

Some French electrical works have produced vanadium alloys and the London Alloys Syndicate later tried unsuccessfully to market ferrovanadium.

Sulvanite‡ is a new vanadium mineral, found in considerable quantities in a mine near the Burra mine, South Australia. It is the first sulphide mineral containing vanadium as one of its principal constituents and has the composition $3Cu_2S,V_2S_5$. It is massive, with a metallic to submetallic luster, bronze yellow color, nearly black streak. Its hardness is 3·5 and sp. gr. 4·03. It is associated with malachite, azurite, quartz, vanadium ochre, gypsum, and calcite, with probably some copper vanadate.

Yttrium.—Muthman and Böhm§ utilize the neutral chromates to effect a separation of the yttrium earths. They were able to make separations in a comparatively little time by means of potassium chromate. In fractionating, the end is most quickly attained by heating the easily soluble bichromates with yellow potassium chromate. The method is applicable to both the cerium and yttrium earths. In the sixth fraction, they obtained yttria which gave an an atomic weight of 88·97; Cleve's results gave 89·02 after a most careful purification by fractional precipitation of the oxalates.

* *Revista Minera*, January, 1901.

† *Engineering and Mining Journal*, Aug. 18, 1900.

‡ *Journal of the Chemical Society*, 77, 1,094, August, 1900.

§ *Berichte*, 33, 42, Jan. 22, 1900.

SALT.

THE total production of salt in the United States, including that used for the manufacture of alkali and heavy chemicals, was 20,738,729 bbl. of 280 lb., against 19,861,948 bbl. in 1899. In the States of New York, Michigan and Kansas, whose combined output amounts to about 85% of the total, the increase has been most marked, while the output marketed in Utah and California was less than for several years past.

PRODUCTION OF SALT IN THE UNITED STATES. (IN BARRELS OF 280 LB.)

Year.	California	Illinois.	Kansas. (d)	Louisiana.	Michigan (c)	Nevada.	New York. (c)	Ohio and W. Virginia. (b)	Utah.	Other States. (c)	Total Barrels.	Total Short Tons.
1896.....	462,450	55,660	1,624,121	173,117	4,321,144	7,818	6,714,394	1,829,771	178,393	343,440	15,707,908	2,199,107
1897.....	484,650	58,764	1,224,980	209,392	5,470,621	5,540	6,172,631	1,010,300	657,340	528,705	15,822,923	2,215,209
1898.....	667,293	57,796	1,810,809	120,300	6,728,005	5,325	7,625,809	1,044,036	121,429	515,592	18,756,394	2,625,895
1899.....	590,386	54,500	2,172,000	357,143	6,699,060	5,900	7,726,172	1,215,000	448,132	594,555	19,861,948	2,780,677
1900.....	455,271	55,000	2,350,000	386,744	6,845,685	5,786	8,123,550	1,688,286	267,857	560,550	20,738,729	2,903,422

(a) Amount inspected. (b) Includes the production of Pennsylvania. (c) Includes salt used for the manufacture of alkali. (d) Output in 1900 is estimated.

Imports and Exports.—The imports of salt during 1900 were 415,775,592 lb. ($633,192) as against 386,378,938 lb. ($587,103) in 1899; the exports of domestic salt amounted to 15,021,861 lb. ($65,410) in 1900, against 25,200,191 lb. ($86,465) in 1899 and the exports of foreign salt were 3,548,724 lb. ($3,907) in 1900, as against 5,216,112 lb. ($9,858) in 1899.

California.—The companies located in the tide water lands around San Francisco Bay have entered into a combination for the purpose of securing better market conditions. Since the contract system was given up the industry has been demoralized by overproduction and low prices. An independent company was organized during the year, and lands were secured in the vicinity of Alvarado, with a view of commencing production in 1901.

Kansas.—The industry has been in a prosperous condition during the past two years; prices have averaged 35c. per bbl. in 1899 and advanced slightly in 1900. The demand for rock salt which is made at Lyons and Kanopolis has remained constant. Hutchinson is the center of the brine industry.

Louisiana.—The Avery Rock Salt Mining Co., with mines on Avery Island, and The Gulf Co., at Belle Isle, were the only producers in 1900. The Myles Salt Co., Ltd., is erecting works on Weeks Island.

Michigan.—The production of salt exclusive of that converted into alkali was 4,820,685 bbl. At the close of the year there were seven new works under construction, while five old works were being remodeled and enlarged. Salt is manufactured in Saginaw, Bay, St. Clair, Iosco, Midland, Manistee, Mason and Wayne counties.

New York.—Almost the entire production of evaporated salt was made by the works under the control of the National Salt Co., which also operates in Michigan, Ohio, West Virginia and other States. The balance sheet of this company for the year ending July 31, 1900, shows total assets of $13,713,403, including plant and construction account, $8,526,276; stock of constituent companies, $3,159,005; merchandise, salt and supplies on hand, $1,080,283; treasury stock, $97,745; cash in banks, accounts and bills receivable and various other items, $851,093. Under liabilities are given capital stock, $12,000,000; deferred payments and securities purchased, $300,000; accounts and bills payable, $758,-738; supplies, $654,665. Prices were maintained at a high level throughout the year. In the table of production 2,850,000 bbl. is included in the figures for 1900, which represents salt and brine used by soda manufacturers. This product is valued at 25c. per metric ton. The output of the Onondaga Salt Association, which is independent of the National Salt Co., was 633,311 bbl.

Utah.—The production of the various salt products in 1900 was as follows: Refined salt 15,000 short tons, crude stock salt 4,000 tons, coarse salt for chlorination 15,000 tons, natural rock salt 3,000 tons, artificial rock salt 500 tons, total 37,500 tons. The rock salt came from Juab and Sevier counties, while Salt Lake County contributed the remainder of the output, excepting 1,000 tons of crude solar salt made in Davis County. The industry in Salt Lake County is controlled by the Inland Crystal Salt Co., which has a large refinery at Saltair. Prices in 1900 were held at a point below that at which the product could be shipped from other fields and manufacturers made reasonable profits.

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (*a*) (IN METRIC TONS AND DOLLARS.)

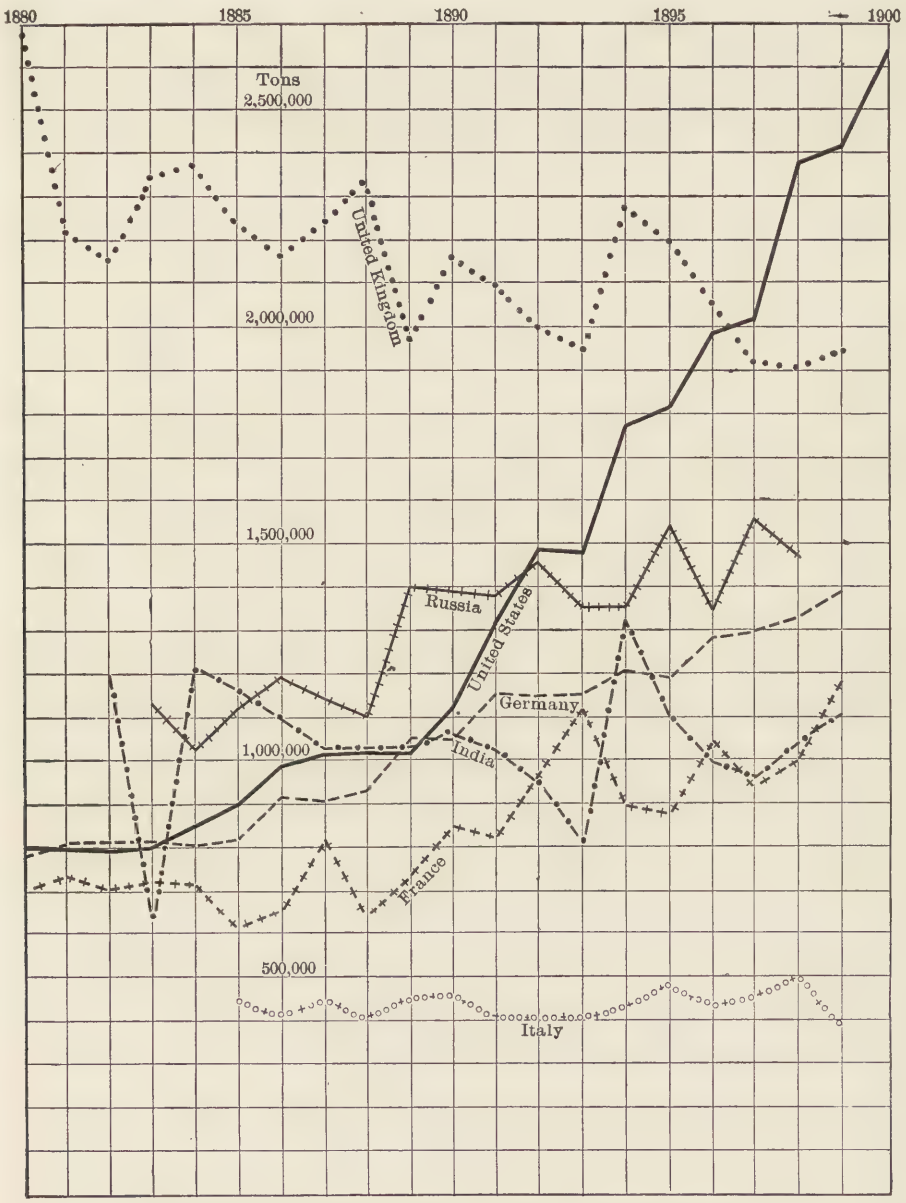
Year.	Algeria.		Austria. (*d*)		Canada.		France.		Germany.	
1895.....	25,758	$102,990	278,875	$11,472,855	47,515	$160,455	871,312	$2,406,155	1,212,336	$4,340,321
1896.....	19,658	85,121	308,932	9,309,068	39,880	169,693	1,042,614	2,473,568	1,303,319	4,416,952
1897.....	23,222	78,058	331,084	10,357,496	46,584	225,730	948,000	2,239,823	1,306,684	3,834,426
1898.....	21,300	86,000	341,959	10,795,700	51,796	234,520	999,283	2,115,120	1,370,341	3,954,743
1899.....	17,378	67,300	342,059	102,76,631	51,796	234,520	1,193,532	2,506,832	1,432,181	3,978,750

Year.	Greece.		Hungary. (*d*)		India.		Italy. (*e*)	
1895.....	22,238	$335,800	169,395	$6,456,480	1,120,832	(*b*)	29,315	$110,190
1896.....	22,800	344,280	180,133	6,191,861	1,043,172	$1,097,909	29,274	113,322
1897.....	20,421	308,357	171,711	5,375,788	937,888	975,260	31,526	117,504
1898.....	37,125	579,150	178,551	5,679,534	1,043,828	1,485,702	29,745	120,715
1899.....	22,411	336,165	182,593	5,479,782	977,240	1,324,748	28,842	64,418

Year.	Russia.		Spain.		United Kingdom.		United States.	
1895.....	1,540,194	$2,383,743	326,320	$952,098	2,208,025	$3,548,755	1,813,135	$6,472,892
1896.....	1,346,247	3,026,000	521,751	1,153,880	2,054,715	3,333,065	1,995,017	5,328,250
1897.....	1,551,894	2,711,077	508,606	1,159,294	1,933,949	3,104,490	2 009,625	3,898,556
1898.....	1,490,000	(*c*)	479,358	1,025,682	1,908,723	3,100,575	2,382,197	4,753,664
1899.....	(*c*)	(*c*)	598,108	1,091,133	1,945,531	3,220,870	2,522,610	5,437,941

(*a*) From the official reports of the respective countries. For Austria, Hungary, Russia, Spain, and the United States, the production of all kinds of salt is given; Germany, rock salt and common salt; Greece, sea salt; France, rock and sea salt; Algeria, sea and rock salt; Italy, rock and salt from brine; United Kingdom, rock and brine salt; India, salt which is liable to British salt tax only, and does not include salt made in certain native States. (*b*) Not reported in the official statistics. (*c*) Statistics not yet published. (*d*) The high valuation of salt in Austria and Hungary is due to the government monopoly of production and high taxation. (*e*) Rock and brine salt only. About 400,000 tons of sea salt is made annually.

Canada.—The output in 1900 was 62,055 short tons, valued at $279,458, while the imports amounted to 92,797 metric tons, valued at $325,433.



THE WORLD'S PRODUCTION OF SALT IN METRIC TONS.

India.—The annual output amounts to about 1,000,000 metric tons, a quantity insufficient to meet the home demand and about 400,000 tons are annually imported from the United Kingdom and Germany.

Italy.—Small quantities of rock and brine salt are made on the Italian Peninsula under government monopoly, while in Sicily there is an extensive industry based on the manufacture of sea salt that is free from government control. The output of sea salt in 1899 was 363,826 metric tons ($514,074) against 451,426 tons ($710,501) in 1898. A large part of the production comes from the Trapani district on the tide water lands between Trapani and Marsala. The process employed is very primitive, but owing to the favorable climatic conditions and purity of the sea water the yield is usually abundant. Evaporation in pans by solar heat is the universal method, windmills being used to elevate the water from the sea. A pan yields from three to five crops during the season of July, August and September. Three qualities of salt are produced known as fine Trapani, coarse Marsala and ground marine salt. Prices are extremely variable and depend upon the export demand and the supply of foreign tonnage. In 1898 the price reached the high mark of 77c. per "salma" of 18 bushels, while in 1899 it fell as low as 54c. The average cost of producing salt is about 16c. per salma.

Japan.—The latest statistics are those for 1897, when the output was 944,039 metric tons, valued at $5,176,625. Rock and brine salt are not found in this country in workable quantities, the production coming mainly from the seacoast. The product is of inferior quality and is used mainly in salting fish. The imports, derived mostly from Germany and China, have increased in the last few years and the government proposes to levy a higher tariff.

Guatemala.—A government contract has been made for the establishment of salt works on the Pacific Coast. The installation must be completed in April, 1902, and the price of salt at the factory shall not exceed $1·75 per 50 kg. The concessionaire shall pay to the government 5% of the net profits of the company for five years. The grant includes 2,000 hectares of public lands and exempts from duty machinery and supplies for installation. At the end of 25 years the government shall have the right to purchase the plant at an appraised value. Solar salt only will be produced.

Mexico.—Salt works have been established in the State of Monterey, where a company has secured an apparently unlimited supply of brine and is now successfully making a fine quality of salt by solar evaporation. The demand for good salt is very large and has heretofore been supplied by an inferior article. The protective duty on this commodity is $20 per ton.

SILICA.

UNDER this caption are grouped the various forms of silica that have a commercial or industrial value, including diatomaceous earth, tripoli, sand, silica brick, flint, pumice, sandstone and novaculite used in the manufacture of grindstones and whetstones. Sandstone for building purposes will be found under the heading "Stone," elsewhere in this volume.

Diatomaceous Earth.—Deposits of diatomaceous earth are found in Nevada, California, New York, Maryland and Virginia. The output in 1900 was 1,375 short tons, valued at $9,675, against 1,136 tons ($8,216) in 1899. The principal uses of the earth are for the manufacture of non-conducting material and refractory brick, for preparing water glass and as an abrasive.

Grindstones.—The production of grindstones in 1900 was 42,039 short tons, valued at $482,462, against 43,959 tons ($501,985) in 1899. Ohio and Michigan are the leading States in this industry, the largest producer being the Cleveland Stone Co., Cleveland, Ohio.

Pumice.—The output of lump pumice was 250 short tons, valued at $1,250, against 340 tons ($1,700) in 1899. The entire amount came from the property of the Chicago Pumice Co., in Utah. There are extensive deposits of volcanic dust or pumaceous sand in western Nebraska, but the material is not utilized.

Quartz and Flint.—There was a large increase in the output of quartz crystal in 1900, the total reported by 13 producers being 35,915 short tons, valued at $84,400, against 24,305 short tons ($56,481) in 1899. The principal mines are located in Massachusetts, New York, Pennsylvania, Maryland, South Carolina and Wisconsin, and the product is used in acid towers, for glass manufacture, as an abrasive, as wood filler and for mixing with china clay to make certain kinds of porcelain. Flint, which is associated with chalk beds, is found in Texas and Florida, but has not been produced to any extent owing to the low price at which the French flint can be imported. It is used for grinding earthen products and ores and in making porcelain. Ground flint or quartz suitable for porcelain is worth about $3 per ton at Trenton, N. J.

Silica Brick.—There was an output of 49,531,000 silica brick, valued at $916,819, against 45,000,000 ($850,000) in 1899. The chief center of the industry is in western Pennsylvania.

Tripoli.—There was an output of 1,846 short tons, valued at $3,987, against 2,102 tons ($4,729) in the preceding year. Newton County, Mo., furnished the larger part of the output, minor quantities coming from Georgia and Massachusetts.

Whetstones.—The subjoined table summarizes the statistics of production of whetstones, scythestones and oilstones in the United States.

PRODUCTION OF WHETSTONES AND SCYTHESTONES IN THE UNITED STATES.

Kind of Stone.	1897.		1898.		1899.		1900.	
	(a) Quantity.	Value.	(a) Quantity.	Value.	(a) Quantity.	Value.	(a) Quantity.	Value.
Hindostan (finished product)	250,000	$5,625	275,000	$8,225	325,000	$9,750	260,000	$10,000
Indiana sandstone (finished product)	200,000	4,000	100,000	2,000	91,000	1,820	70,000	1,750
Arkansas stone ("rough rock")	100,000	4,000	40,000	1,600	60,000	2,400	50,000	2,000
Washita stone ("rough rock")	350,000	4,375	350,000	4,575	350,000	4,575	360,000	5,400
Miscellaneous oilstones (b)	1,677	167		2,500		4,000		7,065
New Hampshire (Indian Pond, etc.)	12,000	33,000	13,000	35,750	13,000	35,750	18,000	54,000
Vermont (Lamoille, etc.)	4,200	14,700	5,000	17,500	5,000	17,500		
Ohio and Michigan grit	18,114	31,362	15,696	36,100		39,425		5,659
Total		$97,229		$107,990		$115,220		$84,874

(a) Quantities given for Hindostan, Indiana, Arkansas and Washita stones and miscellaneous oilstones are pounds; for New Hampshire and Vermont scythestones, and Ohio and Michigan grit the quantities are number of gross. (b) Including Queer Creek, Chocolate, etc., estimated.

The most noteworthy feature of the business in 1900 was the remarkable falling off in the output of Ohio and Michigan grits, used for scythestones. This was due largely to the severe drought that affected the great agricultural district of the Northwest and to the decreased sale of scythes owing to their high price. In the oilstone market an increased sale of India corundum stone was noted, which materially lessened the demand for Washita stone and to a less extent the Arkansas stone. In general the trade may be described as satisfactory.

SLATE.

THERE was a falling off in the production of slate in 1900, the output being 990,036 squares of roofing slate, valued at $2,885,153 and $502,051 slate manufactures, against 1,098,374 squares ($3,055,988) of roofing and $540,434 of manufactures in 1899. The active demand in foreign markets which had a buoyant influence on the industry during the previous two years was less apparent in 1900, and the domestic trade also showed a decline in volume. On the other hand, the prices obtained for roofing slate were better generally than in the preceding year, as the producers abided more closely by their established schedule of rates.

PRODUCTION OF SLATE IN THE UNITED STATES. (*a*)

States.	1899.				1900.			
	Roofing Slate. Squares.	Value.	Mfrs. Value.	Total Value.	Roofing Slate. Squares.	Value.	Mfrs. Value.	Total Value.
California	810	$5,900	*Nil.*	$5,900	3,500	$26,250	*Nil.*	$26,250
Georgia	2,500	12,500	*Nil.*	12,500	*Nil.*		*Nil.*	*Nil.*
Maine	23,412	99,033	$29,364	128,397	19,549	88,988	$46 905	135,893
Md., Pa. (Peach Bottom)	27,959	127,129	*Nil.*	127.129	24,384	114,869	*Nil.*	114,869
Pa. (Chapman's Quarries)	25,300	73,876	*Nil.*	73,876	27,720	95,887	448	96,335
Pennsylva. (other districts)	648,432	1,848,031	442,668	2,290,699	563,014	1,577,614	358,849	1,936,463
Vermont and New York	316,395	711,889	56,642	768,531	307,884	837,844	87,849	925,693
Virginia	53,060	175,630	8,160	183,790	42,985	139,701	5,000	144,701
Other States	*e* 500	*e* 2,000	*e* 3,600	*e* 5,600	*e* 1,000	*e* 4,000	*e* 3,000	*e* 7,000
Totals	1,098,374	$3,055,988	$540,434	$3,596,422	990,036	$2,885,153	$502,051	$3,387,204

(*a*) Not including slate pigment. (*e*) Estimated.

NOTE.—The production of slate pigment, including Baraga graphite and various kinds of mineral black, in 1900 was 6,617 short tons, valued, after grinding, at $72,787, against 4,911 ($50,338) in 1899.

Export Trade.—The exports of slate in 1900 were: Roofing slate, 131,678 squares, valued at $714,916; slate manufacturers, $133,413; total value, $848,329. For the previous year the figures were: Roofing slate, 252,436 squares ($1,114,018), manufactures, $127,733; total, $1,241,751. These valuations include the cost of slate, rail and ocean freights, insurance and handling. The large decrease in foreign shipments was due to the active competition of the Welsh and French dealers, and the prevailing high ocean rates. In the early part of the year the freight charges to London ruled at 15s., which means a transportation cost from the quarry of about $1·78 per square, or $1·97 per square if the shipment is made from New York. As vessel room was scarce and uncertainty prevailed as to future conditions, no extensive contracts could be made, although some Pennsylvania quarrymen shipped a few orders to Great Britain and Germany. The freight rates remained steady throughout the year at about 15s. to London, and 13s. on contract, except in the latter part, when 17s. 6d. to London was asked. A feature of the English trade was the decisive action taken by the Welsh quarrymen to meet foreign competition, which, con-

trary to custom, was done by cutting prices. It is reported that in some cases they made reductions of from 15 to 20%, which would remove all profits for the American exporter. At the close of the year, however, the situation seemed to favor an increase of shipments in 1901, as the extensive quarries at Penrhyn, Wales, were shut down by a strike of the workmen and similar troubles were expected in other quarters. The stocks of slate held by the Welsh operators at the close of the year were sufficient to meet orders for several months, but it appeared that the contest between them and the laborers would be long drawn out as previous ones have been. It is stated that many of the quarrymen have left the district and engaged in other work. The average cost of American roofing slate of good quality sold in the British market in 1900 was about as follows, per long ton: Slate at quarry, $9·60; freight to New York, $3·36; ocean freight, $3·24; unloading, storing, etc., $1·44; total, $17·64.

Slate Manufactures.—Prices for blackboards at the beginning of the year were about as follows: 12c. for 3 sq. ft., 13c. for 3·5 sq. ft., 14c. for 4 sq. ft. The demand was weak and manufacturers competed keenly for orders. There was little change in trade throughout the year except in August, when sales increased largely, the total shipments for the month exceeding those of any similar period in two years. In school slates business was less than in 1899, the decrease in volume amounting to almost 10%; but as the manufacturers had a firm control of the trade, prices were maintained at a high level. It appears that this industry in the United States is gradually declining. The total output in 1900 is estimated by the Hyatt School Slate Co. at 7,500,000 finished slates, and the exports at 25% of this amount. The demand for slate flour was fair, sales being made at $7·50 per ton in bags, and $8·25 in barrels f. o. b. Easton, Pa.

Roofing Slate.—The prices of roofing slate f. o. b. at quarry in 1900 were as follows: Maine, $4 to $7·10; Peach Bottom, $4·75 to $5·35; Pennsylvania Bangor No. 1, $3·25 to $4·50; Bangor Ribbon, $3·25 to $3·50; Albion or Jackson Bangor, $3 to $3·75; Lehigh, $2·80 to $3·50; New York-Vermont prices were: Sea Green, $2·50 to $3·15; unfading green, $3·25 to $4·25; red, $8·50 to $11. For the first few months the demand was dull and orders for home consumption were tied up by labor troubles in the building trades. New prices lists were issued late in the spring in which the quotations on certain sizes of Bangor and Lehigh slate were reduced 25c. per square, while red slate sold 50c. lower all around. When the market showed no improvement the dealers began to compete for business by quoting prices below the schedule rates. In the early part of September trade conditions were somewhat better, but a new price list was issued, making a further reduction of from 15 to 20c. per square in some Pennsylvania grades and from 10 to 15c. in Vermont green slates. At the close of the year business was quiet, but dealers as a rule had less stocks on hand than for several years previous.

Arkansas.—The Memphis Slate Co. was organized during the year to operate at Blue Mountain and Little Rock, and a quarry was opened also in Polk County.

California.—Only one quarry in this State was operated in 1900 and the output was small. There is a good market for slate on the Pacific Coast, but the attempts to supply it from local sources have not met as yet with much success.

It is stated that large beds of good slate were uncovered at the Kelsey quarry in Eldorado County.

Maine.—The output of roofing slate as reported by the five companies in operation during 1900, shows a falling off, although the total value of the product, including mill stock, was somewhat larger than in the preceding year. The shipments to consumers outside of New England were 1,565 short tons. About one-half of the output of roofing slate and all of the manufactures were made by the companies at Monson. During the year the Monson-Burmah property was transferred to the Monson Consolidated Slate Co.

Maryland.—The Peach Bottom district experienced a very favorable year and the quarrymen were able to maintain prices at about 25c. per square above those of the previous year. The slate was in demand for filling Government orders, which reduced the stocks materially, while an outlet for some of the product was found in the New England States usually supplied by the Maine quarries. A new feature of the industry in this State was the organization of a company which proposes to utilize the refuse slate in the manufacture of cement, brick and tile. It is planning to erect plants at Delta, Pa., and in Harford County, Md.

Pennsylvania.—The statistics of production for the past year compare unfavorably with those of 1899, although in other respects the results were fairly satisfactory. The falling off in output was due in a large measure to the light export demand, but it is true also that the conditions at many of the quarries were unsuitable for making a large production. A number of the companies were late in commencing work, or had to develop new territory on account of the heavy business of the previous two years, while others were compelled to suspend operations during the strike in the coal regions. On the whole the prices obtained in the domestic market were better than in 1899. An important factor in the industry of this State was the American Slate Co. which controlled the output of the American Bangor, Star-Bangor, Bangor Standard, Bangor Southern, Old Delabole-Bangor, Chrome-North Bangor, Ætna Penn Argyl and the Gem slate quarries. The output of the company last year was 80,400 squares of roofing slate, valued at $233,160 and $31,100 of mill stock. The pay-roll amounted to about $180,000.

Tennessee.—A large body of purple slate has been opened at Tellico Plains, the terminus of the Tellico Railway, which is said to possess the requisites of good roofing slate. There are quarries also near McGhees Station that furnish slate of good quality; some shipments were made, but owing to the difficulties of transportation the business could not be made profitable.

Vermont-New York.—There has been very little change in the slate industry of this district during the past year. The production remained nearly stationary, and, while there was a general falling off in exports, the domestic trade showed some improvement. The foreign demand for the unfading green variety continued brisk, large shipments being made to South Africa, Great Britain and the Continent. In red slate, the arrangement entered into by the producers to sell through the H. H. Mathews Slate Co. continued in force and the market throughout the year was well under control.

SODA AND SODIUM.*

THE production of soda in its various forms, as ash, caustic, bicarbonate and crystals, reduced to a basis of 58%, is estimated to have footed up in the United States for 1900, 390,000 metric tons, as against 387,020 metric tons in 1899. Of this amount there was produced as soda ash 264,000 metric tons, as caustic soda 64,000 metric tons, as sodium bicarbonate 29,000 metric tons, and as crystals 33,000 metric tons. All the above figures are stated on the basis of 58%.

The works producing soda products in 1900 were as follows: Michigan Alkali Co., at Wyandotte, Mich., produced soda ash, bicarbonate, caustic soda and crystals: The Mathieson Alkali Co. at Saltville, produced soda ash and bicarbonate and at Niagara Falls, caustic soda: The Solvay Process Co. produced at its Syracuse Works, soda ash, caustic soda, bicarbonate and crystals and at Detroit, soda ash. The Pennsylvania Salt Manufacturing Co. produced caustic soda, bicarbonate and crystals. The Columbia Chemical Co., at Barberton, Ohio, went into operation near the close of the year, producing soda ash. The Acker Process Co. began operation at its new works at Niagara Falls and is producing 77% caustic soda by electrolyzing fused brine. The American Alkali Co. is erecting works at Sault Ste. Marie, Mich., and has acquired from the Commercial Development Co., of Great Britain, the American rights to the Rhodin electrolytic patents.

The year 1900 opened with great activity in the trade. The disturbing conditions, however, which affected all classes of business during the summer and fall were equally effective against the soda industry. The year ended, however, with a resumption of activity and with promise of a continuance of good business conditions. The feature of the present state of the soda manufacturing industry in the United States is the fact that the capacity to produce soda in its various forms has outgrown the ability to consume. A resulting feature of this growth of production has been the gradual reduction of imports from Great Britain, which foreshadows their complete cessation in the near future. The maximum capacity of the various works mentioned above, with the natural soda output in the West, is estimated at upward of 600,000 metric tons of soda, as against a consuming capacity in the domestic market of 425,000 metric tons.

In England the Commercial Development Co. has been in litigation with the Castner-Kellner Alkali Co., the latter claiming that the Rhodin patent is an infringement on those of Mr. Castner. In July, however, the case was decided by the House of Lords in favor of the Commercial Development Co. Abroad competition has been lessened by the purchase of Bowman, Thompson & Co.'s works by Brunner, Mond & Co., of England. The Castner Electrolytic Alkali Co. of London has been formed to obtain control of the Mathieson Alkali Works, using the Castner patents in America. The Castner-Kellner Co. has been

* This section includes bleaching powder and other substances which are not derivatives of sodium but are recovered as by-products in soda manufacture.

amalgamated with the Aluminium Co., of Oldbury, and the plant of the Aluminium Co. has been transferred to the site of the Castner-Kellner Co. at Weston Point.

IMPORTS OF SODA PRODUCTS INTO THE UNITED STATES.

	1896.		1897.		1898.		1899.		1900.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
		$		$		$		$		$
Soda, nitrate..	258,728,960	3,566,744	212,721,600	2,810,187	330,386,560	2,298,240	328,142,080	3,486,313	407,921,920	4,868,520
Soda, bicarb...	4,343,786	60,878	965,669	13,982	280,988	5,794	162,398	5,219	133,137	4,509
Soda, caustic..	47,827,247	859,809	57,742,392	988,318	24,981,873	354,270	13,363,539	186,008	8,403,749	150,530
Soda ash (*a*)...	191,780,537	1,444,417	154,656,060	1,122,867	73,064,707	447,119	56,053,837	425,205	73,815,425	613,379
Oth'r soda salts	1,279,285	40,039	7,927,145	100,989	23,354,295	256,958	26,340,840	355,502	20,351,801	255,293
Lime, chloride.	99,491,335	1,441,600	109,176,451	1,460,799	108,462,828	1,229,978	123,583,061	1,203,344	132,518,478	1,524,205

(*a*) Including sal soda.

Market Conditions.—The average monthly price of domestic 58% ash per 100 lb. in lots of 50 tons or more f. o. b. works, is given in the following table:

Year.	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	c.	Average.
1898.....	53·75	51·25	53·75	50·50	57·50	57·50	51·50	52·50	50·00	59·00	57·50	57·50	54·35
1899.....	57·50	59·20	62·50	66·50	67·50	63·75	68·75	70·00	71·75	80·00	82·50	83·50	69·45
1900.....	86·66	87·50	87·50	82·50	82·50	82·50	82·50	82·50	77·50	77·50	72·50	75·50	81·43

Domestic soda ash in bags sold in New York at 85@95c. per 100 lb. in March, and 64@70c. in October, owing to free selling by second-hands. Large contracts for 1901 and 1902 delivery were taken at 70@90c. per 100 f. o. b. works. Foreign soda ash sold at 80c.@$1·125 per 100 lb. in New York. Advancing ocean freight rates limited imports and caused prices to rise. In England 48 to 58% alkali in bags sold at £4@£5 10s. per long ton, f. o. b. Liverpool. Contracts for 1901 delivery were booked at £4 5s.@£6 2s. 6d.

Domestic caustic soda sold at $2·375 per 100 lb. f. o. b. works in March, and $1·70 in October. Contracts for 1901 and 1902 were large at $1·70@$2·10 f. o. b. works. These prices compare with $1·55@$1·85 at which 1900 contracts were taken in the previous year. Foreign high-test caustic soda sold in New York at $2·30@$2·60 per 100 lb. In the last quarter of the year jobbers controlled the market, forcing prices down to $1·85@$1·875. Abroad makers quoted high-test alkali £9 15s.@£11 10s. per long ton, net cash, f. o. b. Liverpool.

Domestic sal soda sold in January at 60@70c. per 100 lb. f. o. b. works, according to package. In February to middle October the price was 70@80c., and thereafter receded to 50@70c. Concentrated sal soda held at $1·125@$1·75 per 100 lb. f. o. b. works. Foreign sal soda fluctuated in price according to the visible supply here. The highest price was 72·5c. per 100 lb. in April, and the lowest 65c. in February and December. Concentrated sal soda sold at $1·60@$1·75 per 100 lb. in New York. Abroad the English makers of soda crystals reported sales at £2 15s. 6d.@£3 0s. 6d., in bags, per long ton, f. o. b. Liverpool.

The prices of domestic bicarbonate of soda fluctuated little; ordinary grades selling at $1·065@$1·375 per 100 lb. f. o. b. works, and extra grades at $3·25 @$3·50 per 100 lb., f. o. b. works, less the usual discounts. In England makers

quoted ordinary grades at £5 5s.@£6 15s. per long ton, f. o. b. Liverpool in January, 1901.

Prices of domestic bleaching powder were based on the selling quotations of the foreign article and the entire production was under contract with consumers. Of the total imports into the United States in 1900 shown in the table on the preceding page, England furnished about 110,000,000 lb. and Belgium, France and Germany the remaining 33,000,000 lb. The American agents of the United Alkali Co. reported in January, 1900, that they had sold their entire allotment for delivery on contract, and that sales made of their goods in the open market during the remainder of the year were by second hands. The highest selling price for prime English bleach in New York was $3 per 100 lb. in January, and the lowest $1·60 in October. Contracts for 1901 delivery were booked at $1·75@$2·10 per 100 lb. The English makers renewed their agreement with Continental producers. Continental brands of bleach sold highest at $2·375 per 100 lb. in January, and lowest at $1·35 in October, owing to free offerings by second-hands. Contracts for 1901 were taken at $1·75@$2. In England makers quoted prime bleach in hardwood packages at £6@£7 5s. per long ton, f. o. b. Liverpool. Contracts for 1901 delivery were taken at £6 15s. @£7 10s.

Natural Sodium Carbonate.—There was a considerable production of natural sodium carbonate in 1900. The production, reduced to a basis of 58% ash of natural soda in the United States, came from California and Nevada, and amounted to 14,100 short tons ($195,300) as against 10,500 short tons ($147,000) in 1899. The producers were the Inyo Development Co., of California and Nevada; Griswold & Epperson, of Wadsworth, Nev.; Occidental Alkali Co., of Hawthorne, Nev. There was no production from Wyoming in 1900, the works heretofore reported at Laramie having been destroyed by fire. It is stated that they were not a commercial success. A deposit of natural sodium carbonate has been found in a series of shallow lakes near Clinton, Lillooet district, B. C. In one of them, Lake Goodenough, a thick layer of the salt is reported to cover the entire bottom.

Sodium and Potassium Chlorates and Hypochlorites.—A review of these industries during 1900 is given under the caption, "Potash and Potassium Salts," elsewhere in this volume.

*Sodium Nitrate.—Chile Saltpeter.**—The production of sodium nitrate in Chile in 1900 was 1,473,099 long tons, of which 1,431,143 tons were exported. The production in 1899 was 1,360,000 long tons. In October, 1900, a combination among the producers was organized and a 5-year compact has been made, beginning April 1, 1901, by which the export for each year will be fixed. The allotment for 1901 was fixed at 1,417,233 long tons (31,243,000 quintals).

The sodium nitrate industry in Chile has been described by William Newton,† of which the following is a brief abstract. The first exportation of sodium nitrate from Chile was made in 1830, in which year 8,348 tons were exported, an amount that was increased to 1,355,360 tons in 1899 (1,425,000 tons—EDITOR

* For potassium nitrate, niter or saltpeter, refer to the section, "Potash and Potassium," elsewhere in this volume.

† *Journal of the Society of Chemical Industry*, May 31, 1900.

MINERAL INDUSTRY). Sodium nitrate is produced only in the northern provinces of Chile, although a similar product—potassium nitrate—is obtained in India and Burma by washing certain soils. The nitrate district, which lies from 15 to 20 miles inland from the Pacific Coast, has its northernmost limit at Jazpampa, 15 miles east of Pisagua, and continues southward to Lagunas, a distance of 85 miles, from which point a stretch where no nitrate has yet been declared extends to the districts of Tocapilla and Taltal 60 miles beyond. Of the nitrate beds the most important are those in the Province of Tarapaca, situated on the plain of Tamarugal, which extends north and south 150 miles, and slopes westward from the foot-hills of the Andes, with a width of from 30 to 45 miles, to the coast range which shuts it from the sea. The line of the nitrate deposits which, in places, is three miles wide, lies at the junction of this plain and the coast line of hills.

As regards the origin of these nitrate beds two theories have been advanced, both of which lack satisfactory evidence. One assumes that the nitrate is the residue of decomposed seaweed accumulated on prehistoric sea beaches, which through some upheaval were brought to their present level as pampas; the other that it was derived from the decomposition of ancient guano deposits. The best explanation of the nitrate formation in the Chile beds is that it originates from the oxidation of organic materials and ammonia, accomplished by the action of microscopic organisms, "nitrifying germs." In the plain of Tamarugal there is much organic matter, calcium sulphate and percolating water containing sodium carbonate. The drainage of the western side of the Andes, passing through the soil of the plain, is stopped at the eastward or landward side of the coast line of hills and is there evaporated, yielding all the salts that it has dissolved in the long passage through the soil.

At the surface of the ground is a layer of loose blown dust a few inches in thickness, called "chuca," then follows the "costra," a layer of hard rock varying in depth from 1 to 20 ft., below which is the so-called "caliche," the nitrate-bearing stratum—of a thickness varying from a few inches to several feet. The caliche yields in analysis less than 2% H_2O up to 50% $NaNO_3$, over 21% NaCl and over 10% SiO_2, besides small percentages of potassium nitrate, sodium sulphate, calcium sulphate, calcium phosphate, magnesium sulphate, potassium, iron and aluminum iodates. Beneath the caliche there is usually a loose, gravelly layer, below which nitrate is not found. To open these nitrate beds the laborer with a long, steel, chisel-edged crowbar cuts a round, vertical hole about 9 in. in diameter through the costra and caliche. The hole is enlarged below the caliche and a charge of gunpowder or dynamite inserted, which when fired causes an upheaval of ground for some distance around. The laborers then loosen the blocks and separate the costra from the caliche. In this way a trench is worked forward, and the costra is filled in behind. The nitrate-bearing earth is hauled in carts, or, sometimes upon a light railway to the maquina, or place of manufacture, where it is crushed and then boiled in large tanks. From them the nitrate solution is transferred to the crystallizing tanks, where it remains five or six days. The dried crystals containing from 95 to 96% $NaNO_3$ are bagged and shipped to Iquique, and thence to the markets of the world.

Sodium.—Metallic sodium is manufactured in considerable quantities by the Niagara Electro-Chemical Co., at Niagara Falls, N. Y. A part of the product is converted into sodium peroxide, which is a valuable bleaching agent for straw and other perishable materials, and a part is utilized in the manufacture of potassium cyanide. The manufacture of this metal by the Castner electrolytic process is given elsewhere in this volume, under the caption, "Progress in Electro-Chemistry."

Progress in the Electrolytic Alkali and Chlorine Industry during 1900.

By John B. C. Kershaw.

In The Mineral Industry, Vol. VIII., a tabular statement is given, showing the number of electrolytic alkali works in Europe, either in operation or in course of erection, at the end of 1899. The totals given in that table were 19 and 9 respec-

TABLE I.—ELECTROLYTIC ALKALI WORKS IN OPERATION IN EUROPE AND AMERICA IN 1900.

No.	Name of Company.	Locality of Works.	Date Started.	Horse Power Used.	Process Used.
	United States.				
1.	The Castner Electrolytic Co	Niagara Falls..	1898	2,000-6,000	Castner.
2.	The Burgess Sulphite Wood Pulp Co	Berlin Falls....	1900	700	Le Sueur.
3.	The American Alkali Co	Sault Ste. Marie	1901	2,000	Rhodin.
4.	The Ackers Process Co	Niagara Falls...	1901	1,000	Ackers.
	Total power			7,700	
	France and Switzerland.				
1.	Société des Soudieres Electrolytiques	Les Clavaux....	1898	1,000	Hulin.
2.	Société La Volta Suisse	Vernier		1,000	Outhenin Chalandre.
3.	Société La Volta Lyonnaise	Montiers.. / St. Marcel..	1899	1,200	" "
4.	Société des Fives-Lille	Bozel	1900	1,000	Elektron.
5.	Société Industrielle des Produits Chimiques	Lamotte	1900	1,500	"
6.	Société des Produits Chimiques	Monthey	1899	1,200	"
7.	St. Gobain Chemical Co	Chauny			Hargreaves-Bird.
	Total power			6,900	
	Germany.				
1.	Chemische Fabrik Griesheim Elektron	Griesheim	1890	400	All these works now operate the Elektron process, and are under the technical control of the Griesheim Co.
		Bitterfeld	1894	3,600	
2.	Elektrochemische Werke Bitterfeld	Bitterfeld	1891	1,000	
		Rheinfelden	1899	3,400	
3.	Badische Anilin und Soda Fabrik	Ludwigshafen		1,300	
4.	Consolidierte Alkali Werke	Westeregeln		1,300	
5.	Deutsche Solvay Co	Osternienberg.	1896	1,500	Castner.
6.	Vereinigte Chemische Fabrik	Leopoldschall...	1892	250	Spilker & Löwe.
	Total power			14,250	
	Russia.				
1.	Gesellschaft Russki Warschau	Zombkowitz....	1899	1,200	Bitterfeld.
2.	Gesellschaft Russki Elektron	Slaviansk	1900	1,000	Elektron.
3.	Lubinoff, Solvay & Cie	Donetz	1901	1,500	Solvay.
	Total power			3,700	
	United Kingdom.				
1.	The Electro-chemical Co	St. Helens	1895	3,000	Richardson & Holland.
2.	The General Electrolytic Parent Co	Farnworth	1896	20	Hargreaves-Bird.
3.	The Castner-Kellner Alkali Co	Runcorn	1898	4,000	Castner.
4.	The Electrolytic Alkali Co	Middlewich	1901	1,000	Hargreaves-Bird.
	Total power			8,020	
	Other European Countries.				
1.	Austria—Consorbt. Elektrochem. Industrien	Golling	1900	1,000	Kellner.
2.	Austria—Oest. Verein f. Chem. Produktion	Aussig	1899	600	Own process.
3.	Belgium—Solvay & Cie, Brussels	Jemeppe	1898	1,500	Solvay.
4.	Spain—Sociedad Electroquimica de Flix	Flix	1900	3,000	Elektron.
	Total power			6,100	

tively; and adding the four works operating or erecting in America at the end of 1899, a grand total of 32 is obtained. During 1900, this total has not been increased, but some of the works which were in course of erection a year ago, are now operating, and one has ceased to produce. The table on page 598 shows the present position of the electrolytic alkali industry, and is based on the latest and most reliable returns. Works which produce hypochlorites or chlorates only, have not been included, as these are distinct sub-branches of the salt decomposing industry. In the following notes upon the progress of the industry in 1900, the order of the tables has been followed, and under the various headings of Countries and Works, the information given in the tables is amplified by the additional details that have come into my hands during 1900:

*United States.—1.** The Castner Electrolytic Alkali Co. has been formed during 1900 with a capital of $3,000,000 for the purchase and operation of the Castner patents for the United States, and of the Mathieson Alkali Co.'s electrochemical works at Niagara Falls. These works were built in 1896-97, but it is only since October, 1899, that they have been working up to their full power of 2,000 H.P. The whole of the ordinary share capital ($2,000,000) is being issued to the Mathieson Alkali Co. in payment for these works, and $750,000 of the debenture capital is to be expended upon increasing the capacity of the works from 2,000 to 6,000 H.P. It is stated that for the first five months of 1900, the 2,000-H.P. plant has been in continuous operation, and has earned profits equal to $54,000 after making full allowance for depreciation. When 6,000 H.P. is utilized, the proportion of profits to running charges will be increased. Weightman,† gave some details of the plant and machinery in the original works.

2. The Electro-Chemical Co. of the United States of America, which operated the Le Sueur process at Rumford Falls from 1892 to 1899, when the plant was stopped owing to the fall in the selling values of caustic alkalies and bleach, have restarted the process at the mills of the Burgess Sulphite Fibre Co., at Berlin Falls, N. H. Seven hundred E.H.P. is used at this locality for operation of the process, and 16 tons of salt is decomposed per 24 hours. These mills produce 225 tons air-dried fiber per day. According to Weightman, the chlorine is used for direct bleaching of the wood pulp, the sodium hydrate solution being used at a later stage of the same manufacture. I am informed that the process is giving "fairly satisfactory" results.

3 and 4. The American Alkali Co. and the Ackers Process Co.—These two companies—the flotation of which was referred to in THE MINERAL INDUSTRY, Vol. VIII., are still engaged in building operations at Sault Ste. Marie, and at Niagara, respectively. The works on the Canadian side at Sault Ste. Marie will be operating the Rhodin process with 2,000 H.P. in the course of 1901, and the works on the United States side of the fall were running before the end of 1900.

All the electrolytic alkali works in the United States are run by water power. The total amount utilized in 1901 for production of alkalies and bleach will be about 7,700 H.P., and an output equivalent to 11,550 tons 70% caustic and 25,460 tons 35% bleach may be expected.

France and Switzerland.—1. There has been considerable activity in France

* These section numbers agree with those in Table I † THE MINERAL INDUSTRY, Vol. VIII., p. 530.

and Switzerland during 1900 in all branches of the electro-chemical industry, but the number of electrolytic alkali works in operation is still only seven. The Société des Soudières Electrolytiques at Les Clavaux—where the Hulin process was started in 1898—ceased the manufacture of alkalies and bleach early in 1900, in order to take up that of calcium carbide; but the fall in the selling price of the latter has rendered this manufacture less remunerative than a year ago, and the works is now standing idle. It is hardly creditable to the promoters to believe that a process tested upon a practical scale at Modane for several months, should prove unworkable at Les Clavaux, and according to information I have received, the difficulties at Les Clavaux have been partly financial. It is stated that the "Société d'Electrochimie," who work the Gall & Montlaur chlorate process at St. Michel and at Vallorbes, are experimenting with both the wet and dry Hulin processes, and it is possible that a combination of these will eventually be worked at the factories under the control of this company, and at Les Clavaux.

2. The Société La Volta Suisse, with works at Vernier, has increased its capital by $96,000 during the past year. This company works the Outhenin-Chalandre process, and utilizes 1,000 H.P. in the manufacture of alkalies and bleach. According to Guillet,* the cathodes in this process are placed inside porous tubes which act as diaphragms, and are fixed in an inclined position in the cell, in order to allow the hydrogen gas evolved at the cathode to pass quickly away and to be collected as a by-product of the manufacture. The hydrogen gas passes from the upper end of these porous tubes, and caustic soda solution from the lower end in a continuous stream, when the current is passing. The anodes are contained in ebonite bell-shaped chambers, in order to allow the chlorine gas to be similarly collected and carried away from the cell.

3. The Société La Volta Lyonnaise, though formed at a later date than the Société La Volta Suisse, works the same process at Montiers, and at St. Marcel in Savoy, on a much more extensive scale of operations; and the erection of two new factories, one on the Mediterranean seaboard, and the other in the Department Manche is contemplated. At Montiers 12,000 H.P. from the river Isére is available for the manufacure, and 27 turbines each of 500 H.P., direct coupled to a similar number of dynamos, will ultimately be installed. According to Guillet, however,† the works at Montiers had in June, 1900, produced little soda and no bleach, so that the development is occurring more slowly than was expected.

4. The Société des Fives-Lille are reported by Guillet to be using 8,000 H.P. for production of electrolytic alkali and bleach, at Bozel in Savoy, but this figure again is that of the total power available and not of that at present in use. The process used here was to have been that of the Bitterfeld Co., but the amalgamation of the Bitterfeld & Elektron Parent companies has stopped the exploitation of the former company's process at Bozel, and at present only calcium carbide and ferrosilicium are being produced.

5 and 6. The Société Industrielle des Produits Chimiques operate the Elektron Co.'s process at Lamotte with 1,500 H.P. and produce 2,000 tons caustic and 4,500 tons bleach per annum. This works, as in the case of all others using

* *Le Genie Civil*, Nov. 25, 1899. † *Ibid.*, June 30, 1900.

the Elektron Co.'s process, is under the technical control of the parent company. The same process is being used by a Swiss company at Monthey in Switzerland, but this is without the sanction of the Griesheim Co., who state that they are unable to take proceedings for infringement—because Switzerland does not yet possess a code of patent law. In that happy country freedom extends, apparently even to the right of stealing your neighbor's ideas.

7. The St. Gobain Chemical Co. at Chauny near Paris, utilize the Hargreaves-Bird process.

All these French and Swiss works use water power, with the exception of that at Chauny near Paris, where steam power is utilized. The total power now available in France and Switzerland for the manufacture of alkalies and bleach is therefore between 7,000 and 22,000 H.P., and should the whole of this power be devoted to the production of these two staple products during 1901, the output would amount to about 33,000 tons and 72,600 tons respectively. It has been pointed out, however, that at the end of 1900, the works at Les Clavaux were temporarily stopped, and that the two large power installations at Montiers and at Bozel were not being utilized to their full capacity. The French and Swiss output of electrolytic alkali and bleach in 1900, will therefore be considerably lower than the estimate given above. As regards new developments in France and Switzerland, the two new works projected in the north and south of France by the Société La Volta Lyonnaise, have already been referred to.

Germany.—1 and 2. The Elektron Co. of the Griesheim works at Frankfort, and the Elektrochemische Werke of Bitterfeld, continue to work in unison, and to all appearances the new arrangement is a success. A full account of the financial position of these two companies was given in THE MINERAL INDUSTRY, Vol. VIII. In 1898 the Elektron Co., Frankfort, paid a dividend of 16% on its ordinary share capital, and this dividend has been repeated in 1899. This company attacked the problem of the commercial decomposition of salt solutions by electrolysis at a date (1889) when no belief existed in the possibility of the financial success of the attempt, and their dividends of 16% may be said to have been well earned. Those who controlled its operations at this early date, will no doubt note with pleasure that whereas 10 years ago, Germany was practically wholly dependent upon France and the United Kingdom for supplies of bleaching powder, she is now absolutely independent of foreign countries as regards this article; and in 1899 she exported 17,422 tons of bleach, in addition to meeting the home demand. A more striking proof of the progress of the electrolytic alkali and bleach industry, it would be difficult to find.

The Elektron Co. still refuses to publish any details concerning its process, but it is now stated by Ahrens* that it is a mercury process, and that the amalgam is removed from the cell at very short intervals for decomposition. The anodes are of carbon specially treated to render them resistant to the action of the chlorine. The difficulty of making high strength bleach with chlorine evolved at carbon anodes, is due to the admixture of carbon dioxide gas arising from the oxidation of the carbon, but this difficulty has now been overcome. According to Kruger,† the Elektron Co. use a current of air to aid in separating the

* *Zeitschrift für Angewandte Chemie*, Oct. 23, 1900. † *Elektrochem. Zeitschrift*, March, 1900.

unaltered mercury from the amalgam; and in this way no doubt a saving in the capital outlay upon the mercury necessary to work the process, is obtained.

3 and 4. The Badische Anilin und Soda Fabrik and the Consolidierte Alkali Werke carry on the Elektron process at their own works at Ludwigshafen and Westeregeln, respectively; but the technical control of the process is in the hands of the Elektron Co., who presumably receive a royalty and management charges from these two companies.

5. The Deutsche Solvay Co. work the Castner cell and process, at their works at Osternienberg, Anhalt. The power required in the process is generated from lignite, and the output of caustic soda and bleach is stated to be 6,000 tons per annum.

6. No additional information concerning the process or works at Leopoldschall, has been published during 1900.

All these German works employ steam power for generating their electrical energy, with the one exception of Rheinfelden. I estimate the total power now being used in the electrolytic alkali industry in Germany to be 14,250 H.P. Taking the output of 1,000 H.P. as equal to 1,500 tons, 70% caustic soda and 3,300 tons, 35% bleach per annum, the total capacity of the German alkali and bleach works may be placed at 21,375 tons, 70% caustic alkali, and 47,025 tons, 35% bleach per annum. It must be noted, however, that these works are manufacturing other products, and that the whole of this power is not used for production of the two staple articles named above. Potassium carbonate, potassium hydrate, and liquid chlorine are some of these by-products. In 1899 Germany exported 17,422 tons bleach, and 38,932 tons soda, while her imports of the two articles amounted to only 323 tons and 506 tons respectively.

No new electrolytic alkali works were erected in Germany during 1900. Hasenclever reports that a third works is in course of erection at Bitterfeld, but no details of it or of the process to be used have come under my notice. The reason for this cessation of growth is plain, when one studies the significance of the import and export figures given above. Germany is now producing more electrolytic chlorine than she requires for her home industries, and as the sale in most foreign markets is non-remunerative, owing to the tariff, the export of bleach is not a very paying business. In place of increasing the number of electrolytic alkali works at home, she is therefore supplying the brains, capital, and machinery, for the erection of such factories abroad; and nearly every country in Europe now contains a works provided with German plant and machinery, and a German process, for the production of electrolytic alkali and bleach. Such are the rewards for having been first in the field in this new branch of the chemical industry.

Russia.—Three electrolytic alkali works are already operating in the southern districts of Russia, and others are projected. The details are as follows:

1. The Gesellschaft Russki Warschau operate the Bitterfeld process at Zombkowitz. The agreement of 1899 between the Bitterfeld and Frankfort parent companies, respecting the management of all the subsidiary companies and works, did not extend to the Zombkowitz works, which was unfinished at that date. This works utilizes 1,200 H.P.

2. The Gesellschaft Russki Elektron is a company promoted by the Frankfort Elektron Co., with a capital of 1,875,000 rubles, for the operation of their process at Slaviansk in South Russia. This works was expected to be in operation in April, 1900, and is under the technical control of the parent company.

3. The Russian Solvay Co.—Lubimoff, Solvay & Co., of Moscow, have arranged to work the Solvay & Co. form of cell, at Donetz, near Lissitchansk, as a subsidiary factory to their ammonia-soda works at the same place. This works will utilize 1,500 H.P., and it is expected that it will be in operation early in 1901. A total output of 6,000 tons per annum is expected. The cell to be used at this works was patented on March 5, 1898. It is an improved form of Castner's cell, and may be described as a mercury cell provided with a bridge, over which the lighter mercury amalgam floats away continuously, while the salt solution passes in the same direction through the cell. Carbon anodes are used. The cell can be made of large size, and the cost of labor, etc., per ton of products made thereby correspondingly reduced. The amalgam is decomposed by Kellner's method in a second cell, where it functions as anode during the decomposition. A current density of 100 to 200 amperes can be maintained with an E.M.F. of only 3·5 to 4·0 volts in this form of cell, the salt solution being kept at 80°C. in order to reduce the E.M.F.

The above three works will all be operated by steam power, and if no stoppages occur during 1901, the Russian output of both alkali and bleach may be estimated at 17,000 tons. No new works were being planned for Russia at the end of 1900, it being obviously too soon to judge of the success of the electrolytic alkali manufacture in that country.

United Kingdom.—There has been little change to record during 1900 in the position and prospects of the electrolytic alkali industry in Great Britain. No new processes have been brought to a practical success, and no new works have been planned. The protracted litigation between the Castner-Kellner Co. and the Commercial Development Corporation, who own the patent rights for the Rhodin cell, was brought to a close by a decision in favor of the latter company in the House of Lords. This decision does not affect the practical situation in England, as the form of cell over which the battle raged, is not actually worked by the Castner-Kellner Co.; and the Commercial Development Corporation have not yet arranged to work the Rhodin cell in the United Kingdom. The case is of interest to patent lawyers however, as showing how difficult it is to obtain even from judges of the High Court assisted by experts, a unanimous opinion upon patent cases. This litigation was carried through three successive courts, and two reversed the decision of the lower court. In Germany a similar case has been decided in favor of the Castner-Kellner Co. A more striking instance of the uncertainties of the law, and of the value of a long purse, it would be difficult to find.

1. The Electro-Chemical Co. operates the Richardson & Holland process at St. Helens, Lancashire. It was reconstructed during 1900, in order to get rid of the excessive capitalization due to the overvaluation of its patent rights; the new company being registered as The Electrical-Chemical Co., 1900, with

a capital of $960,000. That the patents were of considerably less value than was originally supposed, is proved by the number of stoppages for repairs and improvements which have marked the history of the works at St. Helens. Reference was made in THE MINERAL INDUSTRY, Vol. VIII., to difficulties at the end of 1899. In October, 1900, I received the customary information, that the process had been stopped, pending alterations and enlargements of the works, but that it was hoped to start it again before the end of the month. This company works portions of the old Leblanc process, in conjunction with the electrolytic process, and it is difficult to know what proportion of their output is due to the latter. New patents are being continually taken out, by those responsible for the technical management of this process, but it does not appear that these have yet been successful in surmounting the difficulties met with in working this gravity electrolytic alkali process.*

2. The General Electrolytic Parent Co. still operates the Hargreaves-Bird process at Farnworth near Widnes and during the past year it has declared a dividend of 200% upon its share capital. It is not clear whether this profit has been made entirely by the operation of the small experimental 20 H.P. plant at Farnworth; but if so, it augurs well for the success of the larger company floated at the end of 1899. Two years ago the parent company paid a dividend of 50%; so that the last distribution is equal to one of 100% per annum.

3. The Castner-Kellner Alkali Co. continues to carry on the manufacture of alkalies and bleach by the Castner process successfully at Weston Point, and the works at this place has now reached the limit in size: 4,000 H.P. During 1900 the capital of the company has been increased from $1,440,000 to $2,160,000, and its borrowing powers have also been increased to $1,200,000; $624,000 of the new share capital is to be allotted to the Aluminium Co. of Oldbury in payment for their business. This company was the original owner of the Castner patents for producing alkalies and chlorine, and it was at their works that the Castner cell was first tried upon an experimental scale. Since the sale of the English rights to the English Castner-Kellner Co., the Oldbury works has been used only to manufacture sodium and sodium peroxide. This manufacture is now to be transferred to Weston Point, and the Oldbury works is to be finally closed.

At the fourth annual meeting of the shareholders of the Castner-Kellner Co., held in May, 1900, the chairman stated that the position of the company was improving from year to year. In the year 1899-1900, the gross profits were $285,532, and of this $54,110 was expended upon the maintenance of plant and machinery. The plant at Weston Point is being kept up to a high state of efficiency out of the revenue account, and the above figure shows that the expenditure under this head is heavy. This is a fact too often lost sight of by inventors and promoters of electrolytic alkali companies, and it accounts for some of the past failures. The Castner-Kellner Co. are therefore setting a wise example in charging maintenance and repairs to the current revenue account and in setting aside $48,000 of the 1899-1900 receipts for depreciation. The surplus,

* Early in 1901 this company resolved to suspend operations, and the electrical plant and machinery are now to be sold.

however, still sufficed to pay a dividend of 8% on the ordinary share capital; and the management and shareholders of this company are to be congratulated upon the success of their works at Weston Point.

4. The Electrolytic Alkali Co. has been floated with a nominal capital of $2,400,000 for purchase of the Hargreaves-Bird patent rights, and for erection of a works at Middlewich in Cheshire. This was alluded to in THE MINERAL INDUSTRY, Vol. VIII., p. 529. The whole of the capital asked for at the time of the flotation—$1,440,000—was not forthcoming, but sufficient was received to enable the new company to commence building operations at Middlewich, and in October, 1900, I was officially informed that the plant would be ready to start early in 1901. There has been some difficulty in obtaining the delivery of the generating machinery, and this has delayed the commencement of manufacturing operations beyond the date originally fixed. Steam power is to be used for the first unit of plant, but it is intended to use gas power for one of the succeeding units.

All the English works are steam driven, with the exception of that at Farnworth, which utilizes gas as its motive power. The total power which will be available early in 1901 for the manufacture of electrolytic alkalies and bleach in these four works will be 8,020 H.P. and if the whole of this should be employed during 1901 in producing these chemicals, the output would equal 12,000 tons 70% caustic soda and 26,400 tons 35% bleaching powder. It has, however, been pointed out that the St. Helens works are operating in a very irregular and unsatisfactory manner, and as the Weston Point works are about to take up a new electrolytic manufacture (that of sodium) which will require some portion of their power, no very reliable estimate of the English output of electrolytic alkalies and bleach during 1900 or 1901 can be made.

Other European Countries.—1. At Golling near Salzburg the Kellner processes for production of alkalies and bleaching solutions are in use. Reference was made in THE MINERAL INDUSTRY, Vol. VIII., p. 540, to the cause of the delay which had occurred in the development of these processes at Golling. I have, however, been unable to obtain from Dr. Kellner, any information relating to the present position of affairs at Golling, and presumably the financial difficulties are not yet surmounted.

With reference to further development in Austria and Hungary, the works at Iajce—originally built for calcium carbide—has not proved a great success, and it is now intended to devote some portion of the 8,000 H.P. (water) developed at this spot, to the manufacture of caustic alkalies and chlorine products. Dr. Kellner is also interested in this new undertaking.

2. In Austria the Oest. Verein für Chemische und Metallurgische Produktion are working a gravity electrolytic alkali process at Aussig on the Elbe, with 600 H.P. This process is apparently similar to the original Richardson & Holland process, both diaphragms and mercury being dispensed with. The anode and cathodes are suspended near the surface of the electrolyte, the former in bell-shaped vessels. The difference in the specific gravity of the anode and cathode solutions is supposed to effect separation, and to remove the sodium hydrate as it forms from the path of the current. The experiences at St. Helens,

however, are not favorable to the ultimate success of this process; the difficulty being that undecomposed chloride is always present in large amounts in the solution obtained from the cell. It is said that a solution can be obtained containing from 100 to 156 g. sodium hydrate per liter.

3. At Jemeppe in Belgium the Brussels firm of Solvay & Cie, have started to work their improved Castner cell with 1,500 H.P. (steam). The works was built in 1897-98, and is producing about 6,000 tons of the two products, caustic soda and bleaching powder per annum. For a description of the Solvay cell, see the preceding page.

4. The Griesheim Elektron Co., of Frankfort, has promoted a subsidiary company, for operation of its process at Flix on the Ebro in Spain, and 3,600 H.P. (water) is to be ultimately developed at this spot for production of alkalies and chlorine products. This works is under the control of the parent company, and is now in operation, but it is not known what amount of power is being utilized for the manufactures named. A Spanish company with a capital of $2,880,000 is also said to have been formed for operation of the Hargreaves-Bird process at a locality in the north of Spain; but further details of this new undertaking are lacking.

In Italy I have been unable to hear of any electrolytic alkali works yet in operation, but it is stated that a company backed by German, Swiss, and Italian capitalists, with offices at Lugano, has been formed to erect a works in the plains of Piotta. Power is to be obtained from Lake Ristoni near Bellinzona, where 18,000 H.P. are available. A French process is to be used; and an output of 75 tons alkali and bleach per day is estimated. Further details are lacking.

In Norway and Sweden, there are as yet no electrolytic alkali works in operation, the factories at Stjernfors, Sarpsborg, and at Mansboe, being devoted to the manufacture of other electro-chemical, or electro-metallurgical products, and of bleached wood pulp.

In Table II. the total horse power available, and the estimated output of caustic soda and bleach for the various producing countries in 1901, have been gathered together. It will be noticed that the quantities are much below those given by Borchers in his paper presented to the German Electro-Chemical Society in 1899. The figures in that paper were based upon prospective rather than actual productions, and it will not be until the lapse of a few more years, that the electrolytic alkali industry in Europe and America will show a production of 82,000 tons caustic soda, and 225,000 tons bleach per annum.

TABLE II.—ESTIMATE OF POWER UTILIZED IN 1901 FOR THE PRODUCTION OF ALKALIES AND BLEACH BY ELECTROLYTIC METHODS IN EUROPE AND AMERICA.

Country.	Number of Works.	Total Horse Power.	Estimated Output.	
			70% Caustic Soda.	35% Bleach.
United States	4	7,700	11,550	25,410
Belgium, Spain and Austria	4	6,100	9,150	20,130
France and Switzerland	8	6,900	10,350	22,770
Germany	8	14,250	21,375	47,025
Russia	3	3,700	5,550	12,210
United Kingdom	4	8,020	12,030	26,466
Total	31	46,670	70,005	154,011

A Rotating Cylindrical Furnace for Roasting Sodium Bicarbonate.

By John R. Watson.

The adaptation of the cylindrical type of furnace in the United States resulted from the advantages of automatic action in feeding and discharging and the ease with which the resultant gases can be collected. Considerable thought was involved, and a practical knowledge of the conditions was necessary before the furnace became successful. The rotating furnace as described below and illustrated in detail by the drawing, is the outcome of years of experiment which was necessary to bring it to its present satisfactory form.

The furnace or roaster consists essentially of a cast-iron rotating cylinder divided into two portions, termed the front and the back or feed end. The cylinder is externally heated by means of gas fires, or a coal grate, and attention is called to a few of the construction details.

First should be noted the peculiar form of the front cylinder, which consists of two castings joined together by steel bands riveted to both cylinders, the cylinders themselves having the outer ends in the form of a truncated cone. The reason for this form is that in the roasting of wet sodium bicarbonate to dryness, a large body of hot material must be had in order to prevent the "balling" or "caking" of the wet bicarbonate, which when caked is difficult to decompose.

The back or feed end portion of the furnace consists of two similar cast-iron cylinders, joined together by bands similar to the connection between the cylinders of the front end. The front and back cylinders are connected by a flange joint, well bolted and secured, the flanges being turned to a slight taper so that a steel tread can be shrunk on.

The driving mechanism of the cylinders consists of a spur wheel bolted to the back end, operated by a pinion, which in turn is driven through shaft and gearing from a main belt pulley. The connected cylinders are supported by three sets of flanged rollers running in water-cooled troughs which are formed in the bed plates of the castings that support the journal boxes of these rollers. The center set of carrying rolls are fixed longitudinally, while the end rolls have a clearance provided for the expansion and contraction of the cylinders by means of the long shafts and the clearance between the journal boxes.

The furnace, being divided into two portions by the center supporting wheels and main driving gear, necessitates a double system of enclosing the cylinders for the application of external heat. The method devised to meet the condition is clearly shown in the following illustration. A fire-brick arch is turned over the whole of the front and back portions, provision being made for the firing and for conducting the heat to the back portion underneath the center gearing through passages made in the foundations for this purpose.

A chamber is provided in the foundation of the back portion through which the waste gases pass. This contains a hot blast arrangement consisting of 6×8-in. oval pipes placed in the form of a U and an inverted U coil or serpentine, and air from a fan is forced through this being led to the front end by flues or by cast-iron pipes built in the side walls for this purpose.

The best method of firing these furnaces is by gas. If coal grates are used

a mechanical underfed stoker is most suitable, although with hand-firing very good results are obtained. When gas fires are used, a special form of combustion or mixing chamber is necessary so that the hot gases are not concentrated at one place on the cylinders. A very good form is one in which a series of flames are formed the full length of the first cylinder.

Attention should also be given to the feeding device which consists essentially of a vertical and horizontal conveyor of special design as well as to the arrangement for the withdrawal of the gases, ammonia, carbon dioxide gases and water vapors resulting from the decomposition of sodium bicarbonate.

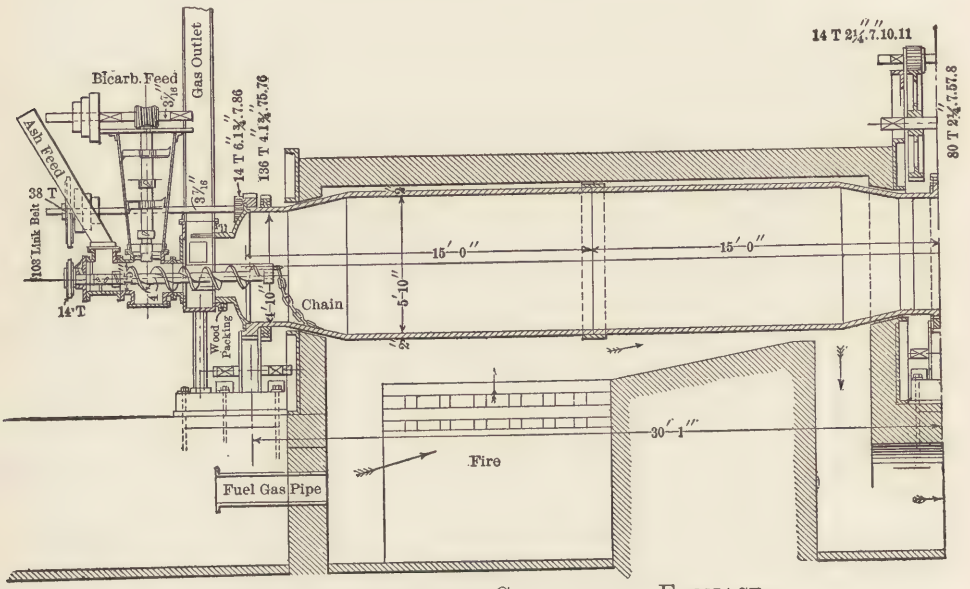


FIG. 1.—A ROTATING CYLINDRICAL FURNACE.

The arrangement is especially noteworthy on account of the difficulty of conveying wet sodium bicarbonate and at the same time drawing off the wet gases resulting from the decomposition before mentioned. The wet bicarbonate is fed through the vertical feed box to the horizontal conveyor, and is there met by a given portion of dry hot ash, fed by means of the chute to a prolongation of the horizontal conveyor. The vertical feeding device has the jacket tapered toward the lower end in order that a solid mass of wet bicarbonate or core will be formed, and thus leakage of air prevented, otherwise the strength of the carbon dioxide gas resulting from the decomposition would be reduced.

The air-tight joint between the furnace-head and the feeding device consists of a stuffing box and gland of special form. An ordinary packing would be useless on account of the temperature, and the special packing of hard maple blocks proved the most efficient. These are shaped and lap one another on rabbits formed for the purpose. The blocks are held in place by the gland composed of an L ring in halves, bolted to the gas box in the usual manner.

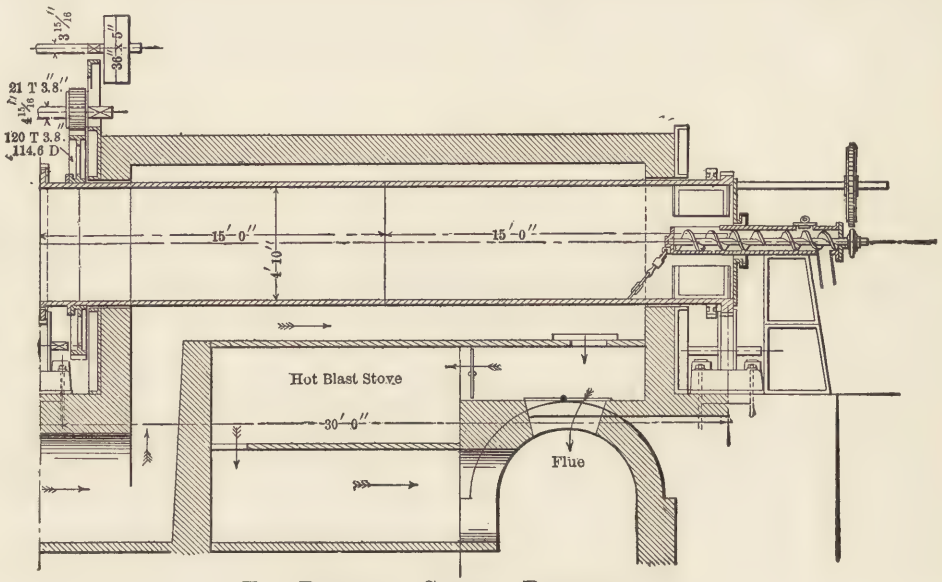
Further attention should be given to the head of the furnace which consists

of a dished head with a neck projecting into the gas box. Knives are fastened to the end of this neck which, rotating with the cylinders, keep a passage clear for the withdrawal of the gases.

The tail-end journal of the horizontal feed conveyor extending into the furnace carries the end of the mixing chain formed of portions of 7-in. I beams connected by double links and pins. The pieces of I beam are cut into the shape of a rhomboid, having the ends inclined to the flanges at an angle of 30°.

The soda ash is discharged in four plates which elevate it and drop it into the discharging conveyor, consisting of a screw conveyor 12 in. in diameter.

The cast-iron conveyor box is circular in section where it passes through the



FOR ROASTING SODIUM BICARBONATE.

end cover and is provided with a stuffing box and gland similar to the one at the front end.

The portion of the conveyor projecting into the furnace resembles the letter U in section. In order that a perfect seal shall be maintained on the furnace, a core of ash is formed by leaving out a portion of the screw of the conveyor.

The average speed of furnace rotation is four revolutions per minute and 12 H.P. are used. The capacity in 24 hours is 30 tons of soda ash. The life of the front cylinders has not as yet been properly determined, but three years has been attained without a large repair cost.

STONE.

THE leading varieties of stone produced in the United States in the order of their importance are limestone, granite, sandstone, marble and slate. Detailed information as to the important quarrying centers, character of their output, and the relative value of stones for different uses, will be found in the review by Charles L. Whittle and William Beals, Jr., in THE MINERAL INDUSTRY, Vol. VIII. The subject of slate is treated under a separate caption in this volume.

The production of stone in 1900, not including sandstone used for the manufacture of grindstones, which is reported under silica and slate, was about $45,066,708, against $43,075,525 in 1899, divided as follows, with the corresponding estimates for 1899 in brackets: Granite, $13,500,000 ($13,000,000); limestone for building, $16,000,000 ($15,000,000); limestone for flux, $3,666,708 ($3,475,525); marble, $4,800,000 ($4,600,000); sandstone, $6,200,000 ($6,000,000); bluestone, $900,000 ($1,000,000). It is practically impossible to carry on from year to year a complete statistical investigation of the various branches of this industry, and hence the above figures are to be regarded only as approximations. The number of the producers is very large, reaching into the thousands, and a considerable portion operate on a small scale, or irregularly, and keep no account of their business. Furthermore the value of the product is largely determined by the costs of labor and transportation, which often vary to a marked degree within the bounds of a single State.

The stone industry generally was prosperous in 1900, as is evidenced in the increased output. In some centers, business was tied up by labor troubles, a notable instance being Chicago, where all the building trades were involved in a strike that lasted nearly the entire year. There has been a large increase in the sale of crushed stone for concrete work and for road building and railway ballasting. This branch of the industry has been placed on a permanent footing in several States by public contributions in the improvement of highways. State laboratories have also been established for the testing of road metals, free of charge.

SULPHUR AND PYRITES.

THERE was a decided increase in the production of sulphur in the United States during 1900, the output amounting to 4,630 long tons as against 1,565 tons in 1899. Nevada contributed the greater part of the total output and the balance came mainly from Utah. The sulphur mines near Lake Charles, Louisiana, were reopened during the year and about 50 tons of sulphur were produced therefrom.

SULPHUR PRODUCTION, IMPORTS, AND CONSUMPTION IN THE UNITED STATES.

Year.	Production.			Imports.								Consumption. (a)	
	Sulphur.			Crude.		Flowers of Sulphur.		Refined.		Totals.			
	Long Tons.	Value.	Value per Ton	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value	Long Tons.	Value.	Long Tons.	Value.
1896	3,800	$72,200	$19·00	145,318	$2,085,076	665·00	$13,266	447·00	$8,226	146,430	$2,106,568	149,746	$2,170,233
1897	1,690	34,814	20·60	138,846	2,442,420	319·00	7,950	148·00	3,387	139,313	2,453,757	140,809	2,484,589
1898	2,726	59,754	21·92	159,790	3,081,974	507·00	14,548	163·00	4,391	160,460	3,100,913	161,772	3,128,845
1899	1,565	33,585	21·46	140,841	2,494,387	336·00	9,917	184·00	4,519	141,361	2,508,823	142,449	2,531,604
1900	4,630	102,091	22·05	166,457	2,918,610	628·00	17,437	243·00	6,279	167,328	2,942,326	171,418	3,030,922

(a) In calculating the consumption of sulphur the exports were taken into consideration, although they do not appear in the above table, viz.: 1896, 484 long tons ($8,535); 1897, 194 long tons ($3,982); 1898, 1,414 long tons ($31,822); 1899, 477 long tons ($10,804); and 1900, 540 long tons ($13,495).

Prices.—The average monthly price of seconds and thirds during 1899 and 1900 is given in the following table:

AVERAGE PRICE OF BRIMSTONE PER LONG TON IN NEW YORK.

Month.	1899.		1900.		Month.	1899.		1900.		Month.	1899.		1900.	
	Seconds.	Thirds.	Seconds.	Thirds.		Seconds.	Thirds.	Seconds.	Thirds.		Seconds.	Thirds.	Seconds.	Thirds.
January..	$21·41	$19·75	$21·79	$19·79	May.....	$20·44	$18·50	$21·50	$19·50	September	$21·15	$19·25	$23·73	$21·63
February	21·44	20·12	21·97	19·78	June.....	21·07	19·07	21·00	18·97	October...	21·75	19·50	23·00	21·25
March ...	22·87	20·50	21·87	19·07	July.....	21·70	19·43	21·16	19·16	November.	21·70	19·70	22·50	19·94
April.....	21·93	19·80	21·37	19·31	August....	21·44	18·88	22·58	20·25	December.	21·40	19·40	22·18	20·05

Average for 1899: Seconds, $21·46; thirds, $19·49. Average for 1900: Seconds, $22·05; thirds, $19·89.

WORLD'S PRODUCTION OF SULPHUR. (a) (IN METRIC TONS.)

Year.	Austria (d)	France. (c)	Hungary	Germany	Greece.	Italy. (b)	Japan.	Russia.	Spain.	Sweden	United States.
1895.....	830	4,213	102	2,061	1,480	370,766	15,557	190	2,231	*Nil.*	1,676
1896.....	643	9,720	138	2,263	1,540	426,353	12,540	437	1,800	77	3,861
1897.....	530	10,723	112	2,317	358	496,658	12,013	574	*b* 3,500	*Nil.*	1,717
1898.....	496	9,818	93	1,954	135	502,351	10,339	(e)	3,100	50	2,770
1899.....	555	11,744	116	1 663	1,150	563,697	10,241	(e)	1,100	*Nil.*	1,590

(a) From the official reports of the respective governments. The sulphur recovered as a by product by the Chance-Claus process in the United Kingdom, amounting to about 31,000 long tons in 1898 is not included. (b) Crude. (c) Raw mineral; limestone impregnated with sulphur. (d) Crude rock. (e) Statistics not yet published.

Australasia.—Owing to the impetus given to sulphur mining by the increase in price, the New Zealand deposits are now operated. The output is taken by the sulphuric acid makers of the colony and displaces the former imports from Sicily and Japan.

Chile.—The American Sulphur Co., capitalized at $5,000,000, has been organized to develop the sulphur deposits in the Tecorah Mountains, which form the boundary line between Chile and Peru. During 1900 a small output was derived from the mines near Arica.

Italy.—According to Dr. Frank the sulphur producing region of Sicily covers an area extending 160 to 170 km. from east to west, and 85 to 90 km. from north to south. The principal districts are situated in the vicinity of Girgenti, Cattolica, Licata, Caltanisetta, Recalmuto, Zolfari and Comittini, and the deposits have been estimated to contain 65,000,000 tons of sulphur. The sulphur industry of Italy has been described with great thoroughness by G. Aichino in THE MINERAL INDUSTRY, Vol. VIII.

SHIPMENTS OF SULPHUR FROM SICILY TO THE UNITED STATES. (IN LONG TONS.)

Port.	1894.		1895.		1896.		1897.		1898.		1899.		1900.	
	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.
New York	33,150	13,725	35,888	19,975	50,557	17,796	57,174	13,300	49,614	22,475	56,746	26,650	70,446	24,307
Charleston	3,273	12,023	700	8,450	2,330	5,370	1,500	3,630	500	1,600				
Philadelphia	350	5,050	1,200	7,150	500	5,500	199	5,210	1,200	5,400	2,740	8,000	1,600	5,100
Baltimore	600	14,700	1,100	8,620	3,650	10,500	3,798	10,033	2,350	12,015	3,800	8,600	6,800	5,400
Boston	1,017	3,300	2,350	2,600	4,600	700	7,220	1,000	4,500	1,550	600	1,000	1,500	2,500
Savannah	5,695	4,100	3,784	800	8,370	1,025	4,700		1,980				1,750	
Wilmington, N. C.		1,890		650	1,260	1,400		1,550	500	1,200				
New Orleans	2,400		1,700		2,100		3,340		500	2,000		800		3,000
Other ports (*a*)	800	3,700	1,880	2,380	7,975	1,290	4,883	600	18,159	200	19,505		32,852	
Totals	47,285	58,488	48,602	50,625	81,342	43,581	82,814	35,323	79,303	46,440	83,391	45,050	114,948	40,307

(*a*) Norfolk, Mobile, San Francisco, Bangor, Portland, Me., and Portland, Ore.

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1892-1900. (*a*) (IN LONG TONS.)

Country.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Australia	1,200								
Austria	9,096	10,169	11,494	12,170	13,799	15,993	15,796	18,519	21,594
Belgium	5,133	4,358	5,644	6,410	7,527	9,253	8,402	7,481	9,721
France	73,176	89,736	56,932	69,696	76,739	84,895	88,657	96,043	103,647
Germany	14,326	16,259	16,437	15,472	15,680	19,721	27,048	25,923	28,702
Greece and Turkey	14,845	13,840	16,870	16,195	18,556	13,866	24,808	18,656	19,647
Holland	2,183	2,957	2,365	3,335	3,834	3,599	5,646	6,408	18,595
Italy	38,711	54,486	49,895	49,349	54,009	73,052	62,652	87,230	101,073
Portugal	13,490	14,545	8,670	14,562	12,001	7,054	8,257	12,269	10,937
Spain	7,382	3,499	3,445	5,753	5,910	4,039	3,233	7,757	6,187
Sweden and Norway	*b*4,561	*b*6,579	*b*7,887	*b*5,730	*b*14,540	*b*11,226	*b*12,331	*b*12,476	*b*22,681
Russia	14,178	19,730	17,977	17,962	18,752	17,532	12,285	19,211	22,090
United Kingdom	24,853	27,453	22,165	24,043	21,913	24,520	26,983	25,038	23,973
United States	84,450	83,901	105,773	99,227	124,923	118,137	138,435	128,441	155,255
Other countries	3,152	1,680	3,376	7,732	8,562	7,651	12,791	13,569	14,060
Totals	309,536	349,192	328,930	347,636	396,745	410,538	447,324	479,031	558,162
Stock in Sicily at end of year	175,299	210,665	198,513	203,756	222,999	240,367	248,023	277,098	221,204

(*a*) From report of A. S. Malcomson, New York. (*b*) Includes exports to Denmark.

The Anglo Sicilian Sulphur Co., Ltd., reports for the fiscal year July 31, 1900, a net profit of £84,578 after placing £8,500 to a reserve fund for doubtful debts. Dividends to the extent of £36,892 (6%) were paid on preferred shares; £20,750

nas been credited to the general reserve fund, £10,049 to the capital guarantee fund and £19,444 was applied to further dividends.

Japan.—The sulphur deposits of the Island of Etrofu were developed by a Japanese company during 1899 and 1900. On account of the severity of the climate during the winter, mining operations are limited to the summer months. According to the report of Mr. Frazar,* the chief engineer of the company, 10,000 tons of sulphur were mined during 1900 and transported to the sea level, 6,000 of which were shipped to Hakodate, Japan, where a refinery has been established. The remaining 4,000 tons will be refined on the ground at Moyoro Bay.

Peru.—The sulphur deposits at Sechura in the Province of Piura, embrace a large number of veins varying from 1 to 20 ft. in thickness which contain from 50 to 70% S. The district, however, is an absolute desert and to exploit the sulphur beds it will be necessary to construct a railway to the port of Salinas, 25 miles distant.

Russia.—The present annual production of sulphur is less than 1,000 tons, amounting to about 5% of the consumption. The mines at Daghestan have been inoperative for a number of years, owing to the inaccessibility of the region. Vast beds of sulphur have recently been discovered in the Trans-Caspia Province at Kirkh-Choulba, 170 miles from Askhabad on the Trans-Caspian Railway. The deposit is of sandstone, impregnated with sulphur to the extent of 60%, and being at the surface, mining costs but 15c. per ton. According to F. J. Machalske† a plant could be readily established to separate the sulphur from the gangue at a treatment cost not to exceed $1·25 per ton. The cost of transportation to manufacturing centers would probably not exceed the import duty which is 5 kopecks per pood.

Spain.—The sulphur mines at Hellin are operated by the Mineral Industry Society of Hellin district, which is now under the control of the sulphur company of Bilboa; 600 men are employed at the mines and a railroad from the mines to the main line is in contemplation; 35,000 tons of sulphur were produced during 1899, mainly from the Murcia Province.

Venezuela.—The German Exploration Co. has recently commenced work on the sulphur deposits of the Chaguaramas district. The product will be shipped via Carúpano to Europe and the United States.

PYRITES.

Owing to the uniformly prosperous trade throughout the United States the production of pyrites in 1900 was stimulated to the highest tonnage point yet recorded, reaching 201,317 long tons. No new sources of supply have been brought to notice, although developments were continued in localities long known as possible contributors, notably in New York, Virginia, North Carolina, Georgia and Alabama. A more determined effort to prospect in new fields might have been made except for the recent radically changed relations in trade brought about by combinations among the consumers of pyrites which affected the entire

* *Cassier's Magazine*, February, 1901. † *Engineering and Mining Journal*, Aug. 25, 1900.

amount imported as well as nearly all of the domestic product. It may be stated that the purchase in the United States of all domestic and foreign pyrites and other ores used for their sulphur content is controlled by representatives of four trade combinations. These purchases are so large in amount (about 500,000 tons annually) that stocks can be accumulated at any of the seaboard ports and distributed to inland works in quantities, securing lowest freight rates. Under these circumstances foreign ores compete favorably with domestic ores and there is but little incentive to develop home mines of uncertain character.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITES IN THE UNITED STATES. (*a*)
(IN TONS OF 2,240 LB.)

Year.	Production.		Imports.			Consumption.	
1896.....	109,282	$292,626	199,678	47%	1,140,571	308,960	$1,433,197
1897.....	133,368	404,699	259,546	47%	847,419	392,914	1,252,118
1898.....	191,160	589,329	171,879	47%	544,165	363,039	1,133,494
1899.....	178,408	583,323	310,008	47%	1,074,855	488,416	1,658,178
1900.....	201,317	684,478	329,449	47%	1,089,693	530,766	1,774,171

(*a*) These statistics do not include the auriferous pyrites used for the manufacture of sulphuric acid in Colorado.

Market.—Deliveries of pyrites during 1900 were chiefly on consumers' contracts, consequently the prices showed but little change throughout the year. Virginia producers quoted f. o. b. Mineral City $4·50@$4·75 per long ton for lump ore and $4·20 for fines (basis 42% S). Massachusetts miners quoted f. o. b. Charlemont, $5·50 for lump ore and $5 for fines. Imports of foreign pyrites were made chiefly from Huelva, Spain; the Pilleys Island, Newfoundland, deposits having been worked out. The total imports of pyrites into the United States during 1900 amounted to 329,449 long tons, valued at $1,089,693 as against 310,008 long tons, valued at $1,074,855 in 1899. A large part of these imports was consigned to the Pennsylvania Salt Manufacturing Co.

Virginia.—(By W. H. Adams.)—The mines at Quantico have largely increased their output, and extended their operations in many ways; new machinery has been added and the mines may now be classed as fully up to date in methods of operating.

The sulphur mines, 4 miles from Mineral, have worked steadily during the year, and increased tonnages have been shipped, both from underground and from the waste copper-bearing dumps. The large milling and concentrating plant was started during the summer and the adjoining property, formerly the Pyrites Co. of Virginia, was purchased and opened up to a satisfactory extent.

The property of the Pyrites Mining and Chemical Co., 3 miles from Mineral, has been worked almost constantly during the year; the mines were opened to a considerable extent and the buildings which were destroyed by fire in 1899 have been generally rebuilt. Shipments have been constant and the quality improved by the use of better concentration methods.

The Arminius Chemical Co., 2 miles from Mineral, has increased its output and is keeping developments of new territory greatly in advance of all requirements. This property has already produced and shipped over 600,000 tons of pyrites since it was opened 17 years ago, and it is now able to ship 100,000 tons annually.

In these annual statistical articles which have appeared in all the volumes of THE MINERAL INDUSTRY to date, attention has been directed to the possible saving of sulphur from waste gases in metallurgical processes. As an example of the wasteful methods in practice it may be cited that a single chimney in the vicinity of New York has been throwing off sulphur at the rate of 20 tons per day of 24 hours during the 18 years since its erection. This amounts to a loss equaling at least $150,000 annually, the greater part of which could have been saved by initial processes in common use in other countries. By attention to details of construction and by combination of such processes as save each and all the products which are to be found in the pyrites of the Atlantic seaboard, there will eventually be utilized millions of tons of ores now deemed to be of too low grade to mine and concentrate.

WORLD'S PRODUCTION OF PYRITES. (*a*) (IN METRIC TONS.)

Year.	Belgium.	Bosnia.	Canada.	France.	Germany.	Hungary.	Italy.	Newfoundland.
1895	3,510		31,024	253,416	127,036	69,195	38,586	34,879
1896	2,560	2,000	30,586	282,064	129,168	52,697	45,728	27,712
1897	1,828	3,670	35,299	303,448	133,302	44,454	58,320	33,316
1898	147	240	29,228	310,972	136,849	58,079	67,191	33,100
1899	283	430	25,117	318,832	144,623	79,519	76,538	31,500

Year.	Norway.	Portugal.	Russia.	Spain. (*d*)	Sweden.	United Kingdom.	United States.	Totals.
1895	61,994	(*c*)	11,042	60,267	221	9,193	107,371	1,007,732
1896	60,507	(*c*)	11,550	100,000	1,009	10,178	117,782	1,075,191
1897	94,484	210,265	19,380	217,545	517	10,753	128,468	1,295,046
1898	89,763	248,218	(*b*) 20,000	260,016	386	12,302	194,219	1,460,710
1899	(*b*) 90,000	275,658	(*b*) 25,000	319,285	150	12,426	181,263	1,580,624

(*a*) From the official reports of the respective governments except the figures for Spain in 1897, which are taken from C. Le Neve Foster's report. (*b*) Estimated. (*c*) Not reported. Under Portugal is included only the output of pyrites carrying less than one per cent. of copper. Considerable amounts of the richer sulphides are also used in sulphuric acid manufacture. In completing the totals the output in 1894, 1895, and 1896 is estimated at 200,000 metric tons. (*d*) Does not include the production of copper-iron pyrites, from which the copper is extracted.

CONSUMPTION OF SULPHUR IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

	1897.	1898.	1899.	1900.
Domestic production of sulphur	1,690	2,726	1,565	4,630
Imports of brimstone	138,846	159,790	140,841	166,457
Total	140,536	162,516	142,406	171,087
Exports of brimstone	194	1,414	477	540
Consumption	140,342	161,102	141,929	170,547
Sulphur contents at 98%	137,535	157,880	139,090	167,136
Domestic production of pyrites	133,368	191,160	178,408	201,317
Imports of pyrites	259,546	171,879	310,008	329,449
Sulphur in domestic pyrites at 44%	58,683	84,110	78,500	88,579
Sulphur in foreign pyrites at 47%	121,986	80,779	145,704	154,841
Total sulphur consumed in pyrites	180,869	164,889	224,204	243,420
Total sulphur consumed in brimstone	137,535	157,880	139,090	167,136
Grand total	318,204	322,769	363,294	410,556

In the above table the imports and exports are for crude sulphur or brimstone only; the figures of consumption, therefore, differ slightly from those given in the preceding table.

There are many deposits of low-grade pyrites ores not deemed of sufficient value for their sulphur alone, which will eventually be worked for their combined values and treated at a profit by modern methods. In the Southern States there are mines of this character which could produce enormous amounts of both acids

and minerals at prices lower than the present average prices along the seaboard. There are but two mines of any prominence at present marketing their ores to general trade throughout the United States; the others are owned by parties or corporations and the products are consumed in their own works.

New York.—During 1900 there was an increased production of pyrites from the mines of northern New York. In the past this field has received far less attention than it deserved, for, while the ores are generally lean and concentration processes are essential to give the proper percentages of sulphur product, yet the concentrates are very pure and are eminently suited to the purposes of manufacturing sulphurous acids for sulphite paper stock. The same may be said of much of the leaner cupriferous ores found so general throughout the New England States. Where the conditions are favorable for cheap mining and concentration these ores must sooner or later become valuable to the paper makers of that section, as they guarantee a constant and large supply of sulphur at prices much lower than can be expected from outside sources. Experiments with the Bartlett concentrating tables were carried on during 1900 at the Stella mines, DeKalb Junction; best results were obtained with material which sized from 0·125 in. down to slimes, but with ores crushed coarser than 0·1875 in. it was impossible to get a close separation.

Sulphuric and Sulphurous Acids.

There was an increase in the production of sulphuric acid during 1900 which was absorbed mainly in the manufacture of fertilizers. The greater part of the output of sulphuric acid produced yearly does not appear in the market, as consumers of large amounts generally make their own supply. If the entire amount of sulphur and pyrites consumed in the United States in 1900 were converted into sulphuric acid it would have produced 1,403,939 short tons of acid of 66°B. It is not fair, however, to assume that the consumption of brimstone and pyrites is utilized for sulphuric acid manufacture, as large quantities are converted directly to sulphurous acid and used as such in preparing sulphite pulp for the manufacture of paper. It is not possible to obtain statistics of the amounts of brimstone and pyrites used for this purpose, nor for the accurate production of sulphuric acid, though probably the greater part of pyrite consumption is utilized for acid manufacture. There was a considerable amount of sulphuric acid recovered as a by-product in roasting sulphide ores of zinc and copper and auriferous pyrites. The production of acid from this source in 1900 was 85,000 short tons as compared with 59,572 tons in 1899. These figures were reduced to a common basis of 66°B. acid, whereas much the greater part of the production was marketed as chamber acid, which naturally increased the tonnage actually handled.

The principal developments of the industry have naturally been made in the Southern and Middle States. The General Chemical Co. and other manufacturers of heavy chemicals have improved and modernized their plants which has resulted in the increase of their production of sulphuric acid. The proposed combination of The General Chemical Co. and The New Jersey Zinc Co.—the latter owning the Schroeder-Grillo contact process patents for the United States

and Canada—was not consummated, although early in 1901 there was every appearance of success. High-grade fuming sulphuric acid was manufactured at Mineral Point, Wis., by The New Jersey Zinc Co., and the works of the Dupont and Repanno chemical companies at Chester, Pa., were started early in 1901.

The Somerset Chemical Co., of Bound Brook, N. J., whose plant was described in THE MINERAL INDUSTRY, Vol. VIII., continues to be the sole manufacturer in this country of liquid anhydrous sulphurous acid (SO_2). This product is manufactured from sulphur and is mainly used in the extraction of glue and gelatine. It is shipped in carboys, iron cylinders and tank cars, to be used in various chemical and metallurgical processes.

The average price of sulphuric acid, concentrated and chamber, at New York in 1899 and 1900 is shown in the subjoined table:

Month.	Conc. Acid. 66° B per 100 Lb.		Chamber Acid. 50° B. per Ton.		Month.	Conc. Acid. 66° B. per 100 Lb.		Chamber Acid. 50° B. per Ton.	
	1899.	1900.	1899.	1900.		1899.	1900.	1899.	1900.
January.....	$1·10	$1·22½	$11·50	$16·16⅔	July.....	$1·10	$1·20	$11·50	$14·00
February.....	1·10	1·21⅞	11·50	15·12½	August.....	1·10	1·20	11·50	14·00
March.....	1·10	1·20	11·50	14·00	September...	1·10	1·20	11·50	14·00
April.....	1·10	1·20	11·50	14·00	October.....	1·10	1·20	11·50	14·00
May.....	1·10	1·20	11·50	14·00	November...	1·15	1·20	13·75	14·00
June.....	1·10	1·20	11·50	14·00	December....	1·20	1·20	16·00	14·00
					Average...	1·11¼	1·20⅝	12·06¼	14·27 5/12

PROGRESS IN THE SULPHURIC ACID INDUSTRY IN 1900.

BY F. J. FALDING

THE year 1900 will be remembered as the practical commencement of the struggle for existence of the old chamber process.

In his report on the sulphuric acid industry to the International Congress of Applied Science at Paris, on July 25, 1900, M. L. Pierron says of the various contact processes "that for the production of concentrated sulphuric acid the cost of erection is 30 to 40% below that of the chamber process and the manufacturing cost some 15% below. The contact process is also economical of room, requires no nitric acid, and does away with concentration. In the present position of the contact process, it is not yet able to produce weak acids as economically as the chamber process; that as yet the amount of acid made by the new process is not sufficient to affect the markets, but it continues to grow; and that it behooves the manufacturers by the old process to put their works into the best possible manufacturing condition, remodeling those of their plants which have an insufficient or costly output, in order to secure the lowest possible cost of production."

The technical literature and the patent office records of the year disclose extraordinary activity among inventors identified with both processes in Europe as well as in the United States.

There are six contact processes actually in operation; namely, the Badische Anilin und Soda Fabrik, including Meister Lucius und Brüning, the Verein Chemischer Fabriken in Mannheim, the Actien Gesellschaft für Zinc Industrie, Dr. Rabe, Sebillot, the Société l'Anhydride in Paris; not to speak of the various manufacturers, such as Messel in England and Hasenclever at Rhenania, who are using a composite process in which a certain amount of the gas is transformed by

catalysis into SO_3 and the non-combined gas is passed into lead chambers (Pierron). Of these processes 14 plants, four of which are in the United States, have been erected or are actually under construction under license from the Actien Gesellschaft für Zinc Industrie alone. Among these licenses are such concerns as Ludwig Rabeneck in Moscow, Russia, and the Société de l'Ouest at Brest, in France; Berzelius in Bensberg and Feld at Höningen am Rhein; De Beers and Nöbel in South Africa, Nöbel of Paris and Dupont of America.

F. Beyer & Co., of Elberfeld, has erected a plant at Leverkusen, near Cologne, under license from the Badische Anilin und Soda Fabrik.

In the United States the year 1900 will not only be remarkable on account of the first installations of the contact process, but also as marking a distinct advance in the connection between the sulphuric acid manufacture and metallurgical operations. It is true that for a number of years past Matthiessen & Hegeler at Lasalle and the Illinois Zinc Co., at Peru, O., have been making large quantities of acid as a by-product in the metallurgy of zinc, but this acid has been not stronger than 60 to 62°B. and no concentrated acid has been made.

The Nichols Chemical Co., now included in the General Chemical Co., and the Pennsylvania Salt Co., also have produced large quantities of concentrated acid in treating copper ores. During 1900 the Peyton Chemical Co., of San Francisco, has been installing a plant, under license from the New Jersey Zinc Co., which controls for the United States the patents and process of the Actien Gesellschaft für Zinc Industrie (Schroeder-Grillo) for the manufacture of concentrated sulphuric acid by contact process for copper-gold-silver ores.

The American Smelting and Refining Co. at the Kansas City works has also erected a chamber plant for the manufacture of sulphuric acid as a by-product.

The Lake Superior Power Co. at Sault Ste. Marie is also erecting a plant for the manufacture of concentrated sulphuric acid and sulphurous anhydride from waste gas in the metallurgical treatment of the Sudbury nickel pyrrhotites. Some of the waste gas after being purified will be used directly in the manufacture on the spot of sulphite pulp.

The Chamber Process.

In Europe the past year has been marked by further developments and installations of the following modifications of the chamber process, all these having for their object economy in cost of production by increasing the output of a given chamber space—and by reduction in cost of labor, nitric acid and increased yield. The production of sulphuric acid from metallurgical gas has also largely increased in Germany and Belgium from the waste fumes of zinc works and in England, France, Germany and Belgium from the roasting of copper ores.

The Tangential Chambers of Dr. Theodor Meyer.—Two installations of this process have been made in Germany with considerable success, the one by the Nord deutsche chemische Fabrik in Harburg, the other by Dr. Hess at Rensberg. Full descriptions of these works with detailed results are given in the *Chemiker-Zeitung,* No. 57, p. 601, 1900, and in a paper written by O. J. Steinhart and J. L. Vogel in *The Chemical Trade Journal,* July 14, 1900. Dr. C. Glaser, of Baltimore, Md., is the representative in the United States of Dr. Theodor Meyer.

Concentric Chambers of J. Delplace.—Further installations of this plan have been made with, it is claimed, great reduction of chamber space and consumption of nitric acid. No installation of either of these plans has yet been made in the United States.

The Benker System.—In this plan the gas passes from the Glover tower through a dry filtering chamber, the filter bed being composed of refractory material, where it deposits much flue-dust and arsenious acid. This filter is followed by three small chambers and two Gay-Lussac towers. Burner gas is also admitted into the third chamber. Sufficient draft is secured by means of a fan. Water spray is used in place of steam. By these means a high rate of production for the chamber space is secured and the consumption of nitric acid is very low.

Double Glover Towers.—Dr. Niedenführ, of Berlin, in order to diminish the loss of draft in the Glover tower, has substituted two small Glovers in parallel instead of one large one, in several recent installations; thus increasing the surface area while reducing the height. In order to divide the gas equally between the two towers use is made of the apparatus patented by Dr. Rabe.*

Intermediate Columns, Surface Condensers and Cooling Devices.—Further installations of the Lunge-Rohrmann plate columns have been made, with good results. Other installations of intermediate columns packed like Glover towers have been made, and the advantage of using such towers, whatever their construction, is becoming widely recognized.

Bürgmeister has proposed and Hartmann and Niedenführ have installed lead flues passing through the interior of the chambers from top to bottom, allowing a current of air to pass through them. From three to four of these having a diameter of 5 to 6 ft. each, are placed in the first chamber and one or two in the succeeding chambers.

Consumption of Nitric Acid.—M. Pierron gives the following figures of consumption at various works:

Works.	System.	Per cent. $NaNO_3$ per Kilogram of Monohydrate.	Per cent. $NaNO_3$ per lb. of Sulphur Burned (available Sulphur Oxides).
		Kilo.	
Malétra		0·875	2·68
Vieille Montagne	Blende.	0·95	2·909
Trémor	Systeme mixte.	1·00	3·0625
Harburg	" tangential.	1·04	3·185
Rensberg	" "	0·73	2·236
Benker	Marche intensive.	0·9 to 1·12	2·756—3·43
Kuhlmann		0·77 to 0·85	2·358—2·60

Gay-Lussac Towers.—The practice of using two Gay-Lussac towers in series, which has been customary so long in the United States, is also gaining ground in Europe. The first of these towers sometimes consists of a Lunge-Rohrmann plate column. The packing of these towers on the Continent is often of clay cylinders, balls, etc., also of coke. In England coke is still preferred.†

* *Zeitschrift für Angewandte Chemie*, 1900, p. 236. † *Chemical Trade Journal*, No. 27, 1900, pp. 262, 263.

Pumping Acids.—The employment of pulsometers and the Kestner acid lifts is supplanting the use of acid eggs and blowcases. The automatic and continuous action of these apparatus leaves nothing to be desired and obviates the use of large tanks over the towers securing an even, steady flow of acid.

Concentration.—The great bulk of acid is still concentrated in platinum or gold-lined platinum. Cast-iron stills, however, are making considerable headway. The porcelain stepped beaker apparatus of Benker is spoken of highly. An apparatus capable of producing daily about 10,000 lb. of 66°B. or 7,250 lb. of 96 to 98% H_2SO_4, costs $2,000 (10,000 fr.) and the beakers being placed in a close chamber constructed of blocks of volvic lava, break very rarely. In England there has been a diminution in the use of the "stepped breaker" process, owing to nuisance arising from the escape of acid fumes.*

The use of the Kessler still is rapidly becoming very common on the Continent. The fuel consumption is stated to be about 9 lb. of coke or 6 lb. of fuel oil per 100 lb. of 66°B. acid. In England the Kessler rectifying process has been introduced into three registered works, the process leaving little or nothing to be desired as regards the escape of noxious gases.†

General Conditions.—So far as acid making practice on the Continent of Europe is concerned, M. Pierron states that the minimum output of a system per 20 cu. ft. in 24 hours is 2·92 lb. of monohydrate, or in other words, 19·25 to 20 cu. ft of chamber space is required to convert the products of combustion of 1 lb. of sulphur into sulphuric acid. These results are exceeded in many works, for example, at Kuhlmann, where the absolutely normal output is 3·34 lb. of monohydrate to 20 cu. ft. of chamber space, and at the works of Benker who, while retaining the old arrangement, has, by judicious modifications—the use of fans, water spray, etc.—been able to obtain an output of 5·24 lb. of monohydrate to 20 cu. ft. of chamber space.

Such results have been obtained by the use of the following modifications:

(1) Placing intermediate towers between the chambers. (2) Using cooling flues inside the chambers. (3) Diminishing loss of draft by employing two parallel Glovers instead of one. (4) Artificial draft by means of fans which make it possible to secure an output of 4·2 and even 5·25 lb. of monohydrate to 20 cu. ft. of chamber space equivalent to 11·5 to 14·4 cu. ft. of chamber space to the pound of sulphur burned (as sulphur oxides available).

In the United States since 1890 the use of intermediate towers has become almost universal. I am not aware that cooling flues inside the chambers have yet been installed. For some years Glover towers have been built of large sectional area and very moderate height (18 to 25 ft.) and consequently have not seriously interfered with the draft. Fans, first used by Mathiessen & Hegeler more than 15 years ago, are now used in many works with and without intermediate surface condensers and many systems are working with from 10 to 13 cu. ft. of chamber space to 1 lb. actual sulphur (as sulphur oxides available).

The N. P. Pratt System is the only special system being exploited in the United States (other than the Tangential system of Dr. Meyer and the system Delplace by the respective agents of their inventors), a full description of which

* Report of the Chief Inspector, March 27, 1900. † *Ibid.*

by the inventor may be found in *The American Fertilizer,* July, 1900. In this system a certain portion of the gas is withdrawn from the rear end of the first chamber and after having been passed through washing towers is mixed with fresh gas from the Glover tower and returned by means of a fan to the first chamber.

Glover Towers.—Quartz broken to suitable sizes is the material principally used for packing. Volvic lava and highly vitrified chemical brick are used for lining and grills or arches. Such towers have a sectional area of from 100 to 200 sq. ft. and a height of from 18 to 25 ft., according to the size of the system.

Chambers.—The tendency is to construct shorter chambers. In several large systems using artificial draft the gas is divided among two or more leading chambers instead of going to one single chamber—the gas at the rear ends being then mixed, cooled and dried in an intermediate tower or other form of surface condenser and passed to a second chamber. In new construction it is unusual to find more than three chambers in series. In several works the forced system is in use (production intense).

Fans.—The use of fans for producing artificial draft is increasing both in new construction as well as in the old, and with or without intermediate surface condensers. There seems to be a common impression that the use of fans produces undue pressure on the sides of the chambers. This is not so. The fans are used only to create a constant and sufficient draft on the burners and through the chambers and Gay-Lussac towers. In the numerous works in which I have installed fans, sufficient draft on the burners to produce best results and to increase their capacity 50% has been obtained without at any time producing an out-pressure on the first chamber exceeding 4 mm. of water when using the forced system. The average out-pressure will not exceed 3 mm. water and on the last chamber it will vary from nothing to 2 mm. In order to use to advantage the intermediate surface condensers and the great increase in cubic capacity of the Gay-Lussac towers necessary to secure a large output and low niter consumption, some reliable form of securing control of the draft is practically a necessity.

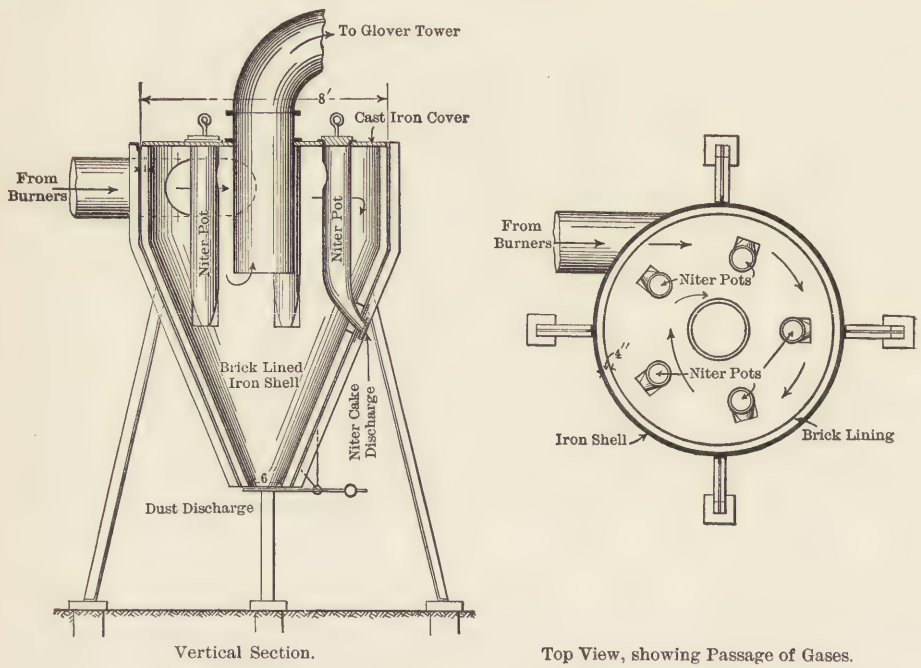
O'Brien Fan.—Mr. A. P. O'Brien, superintendent of the Richmond Guano Co., Richmond, Va., is using successfully a cast-iron fan immediately after the burners and before the niter oven and Glover tower. This cast-iron fan is serving five Herreshoff furnaces and averages 30,000 lb. in 24 hours of Rio Tinto fines 49% S, which is roasted to leave from 1 to 1·5% S in the cinders. The fan has 24-in. suction and discharge, is cast iron throughout and covered with about a 1-in. coat of asbestos cement. The journals are not oiled at all but flooded with water from several small 0·375-in. pipes. Water also surrounds the jacket of each journal and is admitted to the oil chamber as a lubricant. The temperature of the gas inside the fan is about 1,000°F. This fan has been running steadily since June, 1900, and up to February 15, 1901, has not had a cent's worth of repairs or oil. There is nothing special in its construction except that no wrought iron or steel is in contact with the gas—only cast iron.*

Intermediate Towers, Surface Condensers and Cooling Devices.—The inter-

* Private communication from Mr. O'Brien.

mediate towers are made in many ways and packed with many different forms of material. The type packed with brick, quartz, rings, etc., while efficient to a considerable degree, I do not consider of good design or of an efficiency commensurate with cost, as they largely eliminate the consideration of efficient cooling of the gas. The Gilchrist air-cooled condenser is undoubtedly very efficient and is in extensive use. I have recently installed several water-cooled surface condensers which have proved very efficient; they take up very little room and are not costly.

Gay-Lussac towers are nearly all installed two or more in series. They are generally from 40 to 60 ft. high with a sectional area of from 60 to 150 sq. ft. They are lined with vitrified brick and packed with quartz broken in pieces of suitable size, rather large at the grill and quite small at the top.



Vertical Section. Top View, showing Passage of Gases.

FIG. 1.—NITER OVEN POT AND DUST CATCHER.

Pumping Acids.—The use of the acid egg (Montejus) is almost universal. Some few works use the pulsometer to their great advantage and some works use the Pohlé air lift pump or its modification.

Nitration.—Many of the chemical manufacturers who make nitric acid use nitric acid on the Glover tower; but the great majority of fertilizer works still nitrate by means of the niter oven.

In connection with the cast-iron fan alluded to above, Mr. O'Brien uses with very good results an ingenious niter oven, niter pot and dust collector. As a dust collector it is stated to retain about 75% of the dust from the Herreshoff furnaces used—and it is also stated to be eminently satisfactory as a nitrating device.

The niter oven is a tapering hopper-shaped iron shell, cylindrical 8 ft. diameter at top and 12 ft. high, with a 6-in. opening in the bottom for the discharge of flue-dust. It is lined inside with 4 inches of fire brick. A pipe admits the gas from the burners through the above described fan at a high rate of speed tangentially. A central pipe discharges to the Glover. Surrounding the central pipe are a number of special niter pots, preferably six—each pot has a bottom opening outside the oven for running out the acid sodium sulphate and an opening at the top closed by a plug for charging the sodium nitrate and acid and a side opening for escape of the nitric acid into the interior of the niter oven where it is thoroughly mixed with the burner gas before entering the Glover. The pots are set into circular holes in the niter oven top in about the same way as a cartridge is inserted into a revolver and resemble cartridges with the exception of the openings mentioned. The pots can be removed as easily as lifting a stove lid and a new pot immediately substituted. The gas takes a high rotative motion around the pots depositing all the heavy dust which falls to the bottom and is automatically discharged through the 6-in. opening.*

Concentration.—A few works still use platinum entirely and are well equipped with gold-lined Heraeus stills, but the great bulk of acid is concentrated either partially or entirely in iron. The larger and better equipped works concentrate to from 97 to 98% monohydrate and distil a pure 66°B. acid (93·5% H_2SO_4) in one operation.† Some installations of Kessler stills have also been made.

Chamber Acid Manufacture.—A general survey of the manufacture of sulphuric acid by the chamber process in the United States as compared with the condition of the art in Europe, would lead to the belief that while in several of the larger works in the United States the practice both as to management of chambers and concentration is fully up to, and in some respects in advance of the best European practice—the general average in the United States is below the European average, at any rate in France and Germany. Some of the best and some of the worst work in the world is done in this country. This is largely owing to the enormous extension of acid making by the fertilizer manufacturers who have engaged in the manufacture of acid without previous experience. The fertilizer manufacturers, however, are, as a class, clear headed business men and are making rapid strides in this branch of their business. Some of the chamber acid work done in fertilizer works is unexcelled both in output per cubic chamber space and in manufacturing economy.

Roasting Furnaces.—The Herreshoff furnace for fines still holds the front rank. Utley Wedge, Bayonne, has patented two modifications of this furnace, the one an ordinary pyrites roaster, the other a muffle variety. A. C. Johnson, of Baltimore, has patented a variety of the Spence furnace—apparently including the Brown method of protecting the moving parts from heat.

A. P. O'Brien, of Richmond, Va., has devised a new feed for the Herreshoff furnace which is being rapidly adopted. This feed is driven from the main driving shaft of the furnace and not from the moving central column. It is of the screw variety and feeds to the center of the upper shelf. It is operated

* Private communication from Mr. O'Brien.

† "Manufacture of Strong Sulphuric Acid," THE MINERAL INDUSTRY, Vol. VIII., 1900.

by an eccentric and pawl lever and can be adjusted from below out of the heat of the furnace. The ore is also thoroughly dried in the feed tunnel before entering the furnace. Mr. O'Brien has also constructed an entire furnace of the McDougall type involving many excellent ideas but too recent to admit criticism.

The following is a list of plants erected in the United States during the past 18 months, in addition to which numerous existing plants have largely increased their output either by addition or by betterments along the lines indicated above:

LIST OF SULPHURIC ACID PLANTS RECENTLY COMPLETED OR IN COURSE OF CONSTRUCTION.

Name and Locality.	Equipment.	Chamber Capacity. Cubic feet.
Richmond Guano Co., Richmond, Va.	4 Intermediate towers	177,876
E. Frank Coe & Co., Barren Island, N. Y.		225,000
Southwest Chemical Co., Argentine, Kan	15 Gilchrist columns and fans	435,000
Lazaretto Guano Co., Baltimore, Md	9 Gilchrist columns and fans	336,000
Western Chemical Co., Denver, Colo		450,000
Meridian Fertilizer Co., Meridian, Miss	Pratt system	142,500
Bussey & Sons, Columbus, Ga	Pratt system	90,000
Greenville Fertilizer Co., Greenville, S. C		135,000
Tennessee Chemical Co., Memphis, Tenn		135,000
Anderson Fertilizer Co., Anderson, S. C		124,000
Georgia Chemical Works, Rome, Ga		206,000
Dominion Iron and Steel Co., Sydney, C. B		136,500
Philip Carey Manufacturing Co., Lackland, Ohio		158,000
E. Rauh Sons Fertilizer Co., Indianapolis, Ind	2 Gilchrist columns	101,000
Jackson Fertilizer Co., Jackson, Miss	3 Gilchrist columns	220,000
Scott Bros. Fertilizer Co., Elkton, Md		83,000
C. H. Dempwolf & Co., York, Pa		170,000
A. P. Brantley Sons Co., Blackshear, Ga		101,000
Bowker Chemical Co., Cincinnati, Ohio		141,000
Virginia State Fertilizer Co., Lynchburg, Va	4 Intermediate towers	148,000
Graselli Chemical Co., Birmingham, Ala		400,000
Jarecki Chemical Co., Cincinnati, Ohio		140,000

DIMENSIONS OF 64 CHAMBERS INCLUDED IN THE ABOVE LIST.

Number.	Dimensions in feet. Wide. High. Long.	Number.	Dimensions in feet. Wide. High. Long.	Number.	Dimensions in feet. Wide. High. Long.
3	30 × 24 × 40	1	28 × 20 × 25	2	26 × 20 × 45
4	30 × 24 × 50	1	28 × 20 × 46	2	26 × 20 ×100
1	30 × 24 × 55	1	28 × 20 × 50	2	26 × 20 ×115
12	30 × 24 × 60	1	28 × 20 × 65		
		2	28 × 20 × 90	1	25 × 20 × 36
2	30 × 20 × 25	1	28 × 20 ×180	1	25 × 20 ×117
1	30 × 20 × 47			1	25 × 20 ×150
1	30 × 20 × 50	1	27 × 24 × 27		
1	30 × 20 × 70	1	27 × 24 × 46		
2	30 × 20 × 75	1	27 × 24 × 60	1	24 × 22 × 26
1	30 × 20 × 97	1	27 × 24 × 66	1	24 × 22 × 46
1	30 × 20 ×106	1	27 × 24 × 75	1	24 × 22 × 85
1	28 × 24 × 75	1	27 × 20 × 27		
5	28 × 24 × 85	1	27 × 20 × 47		
		1	27 × 20 × 64		
		1	27 × 20 × 65		
		1	27 × 20 × 70		

Forty-seven of these are 75 ft. long or less; 11 are between 100 ft. and 75 ft. long; and 6 are over 100 ft. in length. Of the systems included in the above list, two are of five chambers; three of four chambers; one of three groups of three chambers each; one of two groups of three chambers each; and 11 of three chambers.

Two furnaces for roasting zinc blende of the Rhenania type improved by the Actien Gesellschaft für Zinc Industrie have been erected at Mineral Point, Wis.

United States Patent List, 1900 (partial).

Frank P. Van Denberg, Buffalo, N. Y., has patented* a process of making sulphuric acid, which consists of subjecting a material containing sulphur, such as calcium sulphate or gypsum, to heat and electrolysis produced by an electric current within a furnace and applied directly to the material while in a molten condition in the presence of an excess of free oxygen, thereby forming sulphur oxide and subsequently hydrating this.

Albert C. Johnson, Baltimore, Md., has patented† a process of producing sulphuric acid which consists of causing a series of electric sparks within a chamber containing vaporous sulphuric acid gas and introducing oxyhydrogen gas, which is exploded by the electric sparks, whereby the acid-laden particles of moisture may be precipitated. Two plants are now being equipped with this improvement on the strength of satisfactory preliminary tests.

Process of Purifying Sludge Acids.—Wilson Waring and John E. Breckenridge have patented‡ a process of purifying sludge acids which have been used in the treatment of mineral oils, consisting of mixing with such acids at low temperature, sodium nitrate in quantity only sufficient to purify the acid.

Utley Wedge, Bayonne, N. J., has patented§ a mechanical roasting furnace and a mechanical muffle roasting furnace, both of the McDougall type.

Albert C. Johnson, Baltimore, Md., has patented‖ an ore roasting and desulphurizing furnace of the Spence type.

N. P. Pratt, Atlanta, Ga., has secured a number of patents¶ on the Pratt process mentioned in the first part of this article.

The Contact Process.

The year 1900 has been marked in Europe by the erection of several new plants under license from the manufacturing concerns exploiting special patents, and by various improvements in the several processes. In the United States the first installation of a contact plant was completed early in the year, and the first contact acid made, containing up to 88% SO_3 (equivalent to monohydrate +35% of free SO_3). Three other plants are also in course of construction. So far all the installations in America are according to the methods and using the contact mass of the Actien Gesellschaft für Zinc Industrie (Max Schroeder & Grillo).

The technical improvements have been in two directions: (1) a cheaper and more active contact mass and (2) manufacturing economy, especially as regards consumption of fuel which has been and still is a very considerable item of cost.

It may be recalled that there are, broadly speaking, four contact masses in commercial use: (1) Platinized asbestos, clay, pumice, etc., in various forms; (2) Masses having a base of ferric oxide (burnt pyrites); (3) Masses having a base of cupric sulphate; (4) Mass composed of crust formed of a platinum salt and a water soluble earthy or alkaline salt.

(1) Of this class the platinized asbestos as invented and improved by Winkler and others seems to have reached its highest state of development.

* United States Patent No. 642,390.
† United States Patent No. 659,236.
‡ United States Patent No. 643,578.
§ United States Patent Nos. 648,183, and 654,335.
‖ United States Patent No. 642,334.
¶ United States Patent Nos. 652,687, 652,688, 652,689 and 652,690.

Pierron gives the following methods of preparation:

A. The simplest consists in mixing the powdered asbestos (amianthus) with finely divided platinum (platinum black) with a combustible substance (flour bran, sawdust, cork dust, etc.) and an agglutinative substance (gelatine, gum adragante, etc.).

(Platinum black. There are numerous methods of preparation. Liebig treats platinum chloride in a concentrated potash lye with alcohol and washes the resulting powder successively with alcohol, hydrochloric acid, potash and water. Davy reduced platinum sulphate by alcohol. Vauquelin by calcination of a chloroplatinate. Wollaston and Döbereiner precipitate platinum chloride by zinc. Wöhler submitted an ammoniacal salt of platinum, mixed with shreds of cork, to the action of heat in an open crucible. Others have reduced platinum chloride by a mixture of carbonate of soda and sugar, etc.)

B. Asbestos in small fragments is first impregnated with a platinum salt which can then be reduced by several methods. (*a*) Formerly Winkler brought about the formation of chloroplatinate in the pores of the asbestos by plunging the saturated asbestos into a solution of ammonium chloride. He then dried and calcined it. (*b*) Later he prepared an alkaline solution of soda and of platinum chloride containing a sufficient quantity of sodium formiate to reduce it. The asbestos was plunged into this solution, evaporated in a bain-marie, washed and dried. (*c*) The material saturated with platinum salts after being dried can be submitted to the action of hydrogen, or of gas rich in hydrogen such as ordinary illuminating gas (Döbereiner and Berzelius) or even to the action of hydrocarbon compounds (Duke). (*d*) The methods referred to in paragraph *A* are also available to secure the formation of platinum black.

C. In this method of preparation a mixture is first made of the porous material with an oxide or dry salt of platinum, a combustible material and an agglutinative; it is then dried and reduced.

D. A final method consists of soaking powdered asbestos in the platinum salt, reducing by one of the above mentioned methods, then after the addition of the organic matter, required to secure porosity and the agglutinative, it is molded, dried and calcined.

Platinized asbestos, prepared as described above, with probably some undisclosed modifications used by the various manufacturers, has made the commercial success of the contact process possible. It leaves much to be desired, however, on account of its insufficient porosity, the considerable percentage of platinum required and the inevitable loss of platinum when the mass has become inert and the recovery of the platinum is desired.

(2) The Verein Chemischer Fabriken in Mannheim has experimented with pyrites cinder (ferric oxide) as a contact mass. The result of their work up to the present while highly encouraging can hardly be called successful, as only a partial yield has been obtained. It does not seem improbable, however, that final difficulties will be overcome and the process placed on a commercial basis. The advantages of such a process would be very great, as it would save the purifying of the gas—the cooling and subsequent reheating of the gas—the power necessary to secure draft and other costs connected with the platinum mass

processes—not to mention the saving of the large cost item of the platinum mass itself.

It must be remembered that the Mannheim Chemical Co. has been working with specially constructed furnaces; by accumulating a body of pyrites in pyrites burners and drawing the sulphur dioxide through the body of cinders derived from the combustion of the sulphur, etc., but it has been found that the temperature becomes too high for the formation of sulphuric anhydride and that, unless a large excess of air is admitted to the burners and the gases of combustion are diluted therewith, satisfactory results cannot be obtained and even then the yield is not commercially sufficient.

An exceedingly interesting proposition has been made during the year by Mr. Hans A. Frasch.* To use the words of his patent, he finds "that, in comparison to the amount of ore burned to produce the sulphur dioxide, a much smaller quantity of ferric oxide than the ore produces, will suffice to oxidize (to sulphur trioxide) the sulphur dioxide derived from the burning of a large quantity of ore—so that I can avoid or regulate the heat produced by the combustion of the bulk of the sulphur ore by burning the ore in ordinary ore burners and conducting the sulphur dioxide gases to a converter in which only enough sulphur ore is burned to maintain the proper temperature and at the same time produce fresh ferric oxide for a contact substance. For this purpose I employ a catalytic converter which produces the required quantity of ferric oxide for contact substance and at the same time admits of the complete regulation of the temperature in the converter by the quantity of fresh sulphur ore charged into said converter." The catalytic converter is constructed for down draft and may be supplied with a magazine for self-feeding so that the amount of cinder drawn from the bottom of the shaft regulates the charge of fresh ore and hence the temperature. The heat evolved by the complete oxidation of sulphur to SO_3 being +96·4 calories, of which +71·6 are developed by the formation of SO_2 (that is in the roasting furnace) and +24·8 calories are evolved by the final oxidation to SO_3 in the catalytic converter; the sulphur dioxide gases coming from the burners represent an increase of +24·8 calories, the sulphur charged in the catalytic converter and +96·4 calories. By cooling the gases coming from the ordinary roasting furnaces before they enter the catalytic converter the temperature of the contact mass can be reduced and maintained at a desired degree by adjusting the proportions of sulphur burning in, and sulphur dioxide gases admitted to the catalytic converter. The advantages of such a process are manifest—both on the grounds mentioned above and on account of the retention of the ordinary burners which would enable the process to be applied to the metallurgy of zinc, copper, nickel, etc., by the mere addition of a catalytic converter and the consumption of a moderate amount of pyrites for the production therein of the necessary contact mass.

(3) Verein Chemischer Fabriken and Clemm have also patented a process consisting of the use of copper sulphate at a red heat as contact mass. This salt is mixed with dried clay. After molding the resulting paste, moisture is driven off

* "New Developments in the Manufacture of Sulphuric Acid," *Engineering and Mining Journal*, Sept. 1, 1900, and United States Patent No. 664,630.

by heat. The material has been used as a catalytic mass in the production of chlorine by the Deacon process.

(4) The self-reducing salt is the invention of Dr. Max Schroeder and is the contact mass used by the Actien Gesellschaft für Zinc Industrie at Hamborn. It is claimed that owing to the recent improvements only one-eighth of the platinum is required as compared to the best platinized asbestos. This would indicate that the alkaline salt used possesses catalytic properties itself or else much greater porosity. It is also claimed that as the whole contact mass is soluble in water, with the exception of the reduced platinum, an absolute recovery of the platinum can be made, and furthermore, it can be very readily regenerated in case it becomes partially inert on account of careless purification of the gas.

Some recent patents bearing on the subject of new or improved contact substances are as follows:

Catalytic material, Max Schroeder,* Hamborn, Germany, assigned to Actien Gesellschaft für Zinc Industrie and August Heckscher, of New York. A contact body for use in catalytic processes comprising salt crusts containing a platinum salt distributed through a mass of one or more other soluble salts which serve as a carrier or vehicle therefor, etc., etc.

O. Efrem and J. Klaudy,† both of Vienna. Process for the production of substances of great catalytic activity. The substances are formed by treating a refractory body (such as meerschaum, clay or the like) with powerful acids (as aqua regia, sulphuric acid, etc.) for the purpose of removing or preventing the formation of fusible or hygroscopic salts,—washing the substance, mixing it with a platinum salt and an organic substance, such as sugar for instance, (which serves as a reducing agent, and increases the porosity as well,) and with a volatile acid as hydrofluosilicic acid or hydrofluoric acid which etches the particles, accelerates the reduction and acts to harden and bind the mass. The mixture thus produced is finally molded, dried and freed by heating from all volatile constituents. To produce a body of only a small degree of firmness, but of great porosity, large quantities of volatile solid substances, such as ammonium or mercury salts or organic acids, are used instead of the volatile acid.

To increase the porosity further, the latter substances may be added to the material prepared according to the first method.

The Verein Chemischer Fabriken of Mannheim,‡ claims the use as a contact mass of pyrites cinders fresh from the furnace and before their reactive capacity has been diminished.

Clemm§ patents a method of employing cupric sulphate as a contact mass.

As regards improvements in manufacturing economy—a comparison with the chamber acid costs will show where there is room for improvement and the lines on which such improvements are being worked out.

Cost of Pyrites or Sulphur: Same in both processes.

Cost of Nitric Acid: None in the contact process.

Cost of Labor: Less in the contact process.

Cost of Fuel: Much greater in contact process.

* United States Patent No. 636,925.

† English Patent No. 14,339, of 1899.

‡ German Patent No. 107,995, 1899.

§ French Patent No. 291,093, Nov. 6, 1899.

Cost of Repairs: About the same in both processes.

Cost of Amortization and Interest: Considerably less in contact process.

Cost of Concentration: Practically eliminated from contact process.

It is plain, therefore, that in the contact process, the cost of nitric acid and concentration are practically eliminated with a consequent reduction of the cost of interest and amortization. Labor, repairs and cost of sulphur remain about the same in both processes. Amortization and interest can be further reduced as the contact plant is simplified and the high cost of a platinum contact mass is either reduced or a cheaper contact mass is made available.

The principal item in the contact process is the cost of fuel—rendered necessary.

A.—To supply the power for the necessary draft to overcome the resistance of the contact mass and apparatus generally.

B.—To reheat the burner gases to the point of catalytic activity which have been cooled in the cleansing process.

Recent improvements in the contact process have naturally followed on these lines in addition to general structural simplification of the apparatus:

1. Cheapening of the contact mass as evidenced by the patents quoted above.

2. Lessening the resistance of the contact material and apparatus so as to reduce the required power. The Badische Anilin und Soda Fabrik employ perforated shelves to lessen the resistance. The Verein Chemischer Fabriken, Mannheim, prefer platinized grating or network carried by frames. The new furnace of the Actien Gesellschaft für Zinc Industrie, reduces the pressure required from 12 to less than 2 lb. with the probability of a still further reduction.

3. The utilization of the heat formation of SO_3 to reheat the gas after cleansing.

a.—By utilizing the heat of the pyrites furnaces. P. Babatz, etc.

b.—By utilizing the heat of the conversion of SO_2 into SO_3 in the contact furnaces. Badische Anilin und Soda Fabrik, etc.

Recent patents relating to the contact process are as follows:

P. Babatz,* Rheingonheim, Germany, "for producing sulphuric acid and anhydrous sulphuric acid by the contact process, without the aid of machinery. The distinguishing feature is the heating of the purified gases which enter the contact apparatus by the unpurified gases coming from the roasting grate. The contact apparatus is placed over the roasting furnace between which exit and inlet flues are provided for the impure and purified gases respectively, the latter being further heated in the contact chamber by zigzag movement among the pipes or other enclosures for the contact materials before actually traversing these. Cooling pipes formed as ribbed bodies against which the gases impinge regulate the temperature of the contact chamber. Platinized asbestos, molded into solid or hollow forms constitutes the contact material," etc.

Rudolph Knietsch,† Ludwigshafen, Germany, assignor to the Badische Anilin und Soda Fabrik, patents the cooling of the contact furnace by outside countercurrent of gas or air and regulation of the temperature, etc.

* English Patent No. 1,216, Jan. 19, 1900.

† United States Patent No. 652,119, June 19, 1900.

A patent has been issued to Badische Anilin und Soda Fabrik,* which covers the purification of the gas by steam.

Hans A. Frasch,† above quoted.

E. Raynaud‡ and L. Pierron have obtained patents for the purification of sulphurous gas and the contact process as follows:

Crude sulphurous acid gas is passed through one or more towers charged with porous material, such as Kieselguhr, by which it is absorbed. The material is then heated by a suitable device, whereby the gas is said to be liberated in a pure state. Several towers or columns may be arranged to form a circuit, so that those in which the porous material is saturated may be cut off temporarily, and the gas set free.

In case the temperature be kept uniform, at which combination of sulphurous acid with oxygen is effected by catalytic bodies, the gases are first brought into contact with such bodies containing but a small proportion of platinum (say about 5%), and next with bodies containing about 40% of platinum, and finally with such as contain about 10%. A portion of the gaseous mixture while rich is thus "first converted by the substance of slight richness, and, as it becomes impoverished, it is subjected to the action of substances of greater richness which complete the conversion." The final contact with the poorer bodies causes the re-formation of any sulphuric acid first formed, which may through excessive action, have become decomposed. Or catalytic bodies of uniform richness may be used, by such regulation of the temperature in the successive parts reached by the gases, that the reaction may begin at about 300°C., advancing to 500°, and then declining to about 400°, the variation of temperature acting similarly to the variation in the first example of the richness in platinum of the catalytic bodies employed. Hydrogen sulphide may, after purification, replace sulphurous acid in the process.

Verein Chemischer Fabriken,§ Mannheim, has secured patents that cover improvements in the ferric oxide process and apparatus.

Farbwerke, vörmals Meister, Lucius und Brüning, Hoechst am Main,‖ has secured a patent to regulate the temperature in the contact chamber by mixing the reaction gases therein with cold gases and providing that the gas issuing from the contact chamber shall contain sufficient heat to bring the gas entering to a suitable temperature.

A. Sebillot¶ has patented a process for making weak sulphuric acid for metallurgical processes, by passing a mixture of steam, air and sulphurous acid gas over pumice in a specially constructed apparatus.

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* English Patent No. 15,948. † United States Patent No. 664,630.

‡ English Patent Nos. 16,253 and 16,254, Sept. 12, 1900.

§ English Patent Nos. 1,859 and 3,185, of 1899; also No. 24,748, Sept. 26, 1900.

‖ English Patent No. 285, January, 1899. ¶ English Patent No. 21,616, 1898.

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TALC AND SOAPSTONE.

THE production of fibrous talc in 1900 was about 45,000 short tons, valued at $236,250, showing a large falling off from the figures for the previous year. Of common talc there was produced 7,770 short tons ($60,217) against 6,671 tons ($51,763) in 1899, while the output of soapstone amounted to 18,956 short tons ($189,560) against 20,011 tons ($189,504) for the preceding year.

PRODUCTION AND IMPORTS OF FIBROUS TALC AND SOAPSTONE IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

Year.	Production.									Imports. (*b*)		
	Fibrous Talc.			Common Talc.			Soapstone.			Tons.	Value.	Per Ton
	Tons.	Value.	Per Ton	Tons.	Value.	Per Ton	Tons.	Value. (*a*)	Per Ton			
1896....	51,816	$256,080	$4·94	7,098	$63,585	$8·97	14,350	$143,500	$10·00	1,950	$18,693	$9·60
1897....	52,836	283,685	5·37	10,164	90,908	8·94	16,904	169,040	10·00	799	8,423	10·54
1898....	54,807	285,759	5·21	9,112	78,645	8·63	18,862	158,635	8·41	445	5,526	10·70
1899 ...	57,120	272,595	4·77	6,671	51,763	7·71	20,011	189,504	9·47	254	3,534	13·91
1900....	45,000	236,250	5·25	7,770	60,217	7·75	18,956	189,560	10·00	79	1,070	13·50

(*a*) In reporting the value of their output of soapstone producers generally give the figures for the finished articles which they make. Since a varying proportion of labor enters into these, such figures are apt to be misleading. Few producers are able to name a value of the crude stone, or roughly dressed blocks. We have therefore valued the material arbitrarily at this stage at $10 per ton, except in 1898 when a large production of inferior stone reduced the average. The value in 1899 is that reported by the producers. (*b*) Talc, ground, powdered or prepared.

Common Talc.—Considerable prospecting and development work was done last year in the North Carolina deposits owing to the increased demand and to railroad extension. The talc formation so far as mining is concerned is confined to Swain and Cherokee counties, starting from a point 6 miles east of the Valley River Mountain in Swain County and following the Nautahala River nearly to the Mason County line, thence up the Nelson Creek and across the mountains at an altitude of 2,800 at Red Marble Gap. The formation extends into Georgia, but no talc suitable for grinding into flour has been discovered in that State. The deposits vary in thickness and apparently consist of a series of pockets lying between marble and quartzite, although at times they are entirely enclosed within the marble. J. H. Pratt* believes that they have resulted from the alteration of former deposits of tremolite. The talc is mined by open pits and by shafts and tunnels according to the location of the deposit. The mine blocks of talc are hand-cobbed and sorted into three grades, dried at a temperature of 212°F. and crushed and ground. A final grinding in a buhrstone mill and a subsequent passage through bolting cloth yields a product of quite uniform grade which is marketed in bags.

* *North Carolina Geological Survey, Economical Papers*, No. 3, 1900.

The Fibrous Talc Industry of St. Lawrence County, N. Y.

By C. H. Smyth, Jr.

The most noteworthy event in the fibrous talc industry during the past year was the consolidation of Keller Bros., The American Pulp Co. and The Columbian Talc Co., under the name of The Union Talc Co. This combination of competing interests means a considerable reduction of working expenses and a consequent wider margin of profits, conditions much to be desired in this business where gains at best are narrow. There are now in the field four companies—The International Pulp Co., The United States Talc Co., The Union Talc Co. and the Ontario Talc Co. Eight stopes are in operation of a maximum depth of about 450 ft. These mines are all located on the beds of talc that stretch for a distance of several miles through the towns of Fowler and Edwards. The greater part of the mining is done in and near the village of Talcville, in Edwards.

There have been no recent developments of moment either in the working of mines in the old district or in the discovery of new talc-bearing areas. Indeed, since the existing plants are capable of producing an output far in excess of present demand there is little inducement to seek new fields. It is estimated that the mines and mills now equipped could turn out 100,000 tons of talc ready for market per year. The output for 1900 was about 45,000 tons, of an estimated value of $236,250. These figures show a decrease from the output of several previous years, which fact is to be regarded as indicating a return to a more normal production, the large demand for talc in the past few years having been the result of exceptional conditions. Talc, as a general thing, may be regarded as a staple product for which the demand is apt to be quite constant, varying only with the general business conditions of the country. Of course, the development of new rich regions of fibrous talc would affect the industry, but as yet nothing of this kind has occurred; and the mines and mills of this county are so advantageously placed with reference to railroads and water that it seems unlikely that they will ever be seriously crowded by competition.

A cause of some prejudice against the talc of this region is the grit usually present; and if a talc could be found free from this and possessing the essential fibrous structure it would have the advantage. This grit, as shown by the microscope, consists of quartz in small irregular grains disseminated through the talc, together with partly or wholly unaltered tremolite and enstatite. But the grit is present in amounts so small that it seems unlikely that any other fibrous talc will be discovered containing so small a proportion of objectionable foreign matter. As a matter of fact, for many of the purposes for which talc is used the small amount of grit contained in the St. Lawrence product is of no moment, and when required, a higher grade in which the quantity of grit is very slight can be turned out although of course at a greater cost.

With increased depth of the mines, the talc shows improvement in color. This results simply from the absence of the unfavorable conditions at and near the surface and the improvement will continue only for a depth to which the superficial influences cannot extend. Below this point there should be no marked change as the mines deepen. The process of talc formation is not a superficial

one analogous to weathering in general or to the production of gossan in ore deposits. On the contrary, it is a relatively deep-seated process, operating entirely below the zone of weathering. It is strictly analogous to the change of olivine rocks into serpentine. In both cases the rock is changed in composition, but retains its identity as a structural unit in the earth's crust. Weathering, on the other hand, is a superficial process, taking place above the ground level, and disintegration is its most striking characteristic.

Dr. G. P. Merrill,* more than any one else, has accentuated the essential difference between the two processes, and has insisted upon the importance of distinguishing between them.

In the case under consideration, this distinction is clear. The talc is a product of alteration, and the more complete this alteration, the better the quality of the talc. But such portions of this alteration product as have been exposed to weathering have been injured to an extent varying from slight staining to complete disintegration. As to the precise nature of the weathering process in the talc, no data are at hand, but from the well-known properties of the mineral, it is probable that mechanical disintegration rather than chemical decomposition is the most important factor.

As to the future of the industry, it may be said that there is no indication of a falling off in the producing capacity of the mines, and beyond doubt the output for years to come will be limited only by the demand. The latter may become greater in consequence of new uses that may be found for the talc, but this is unlikely. Experimenting in this direction is frequent, but thus far no important results have been attained. As in the past, a large part, probably 95%, of the talc, is used in the manufacture of paper. The remainder finds application in many different industries, each of which uses only a very small quantity.

* *American Geologist*, XXIV., pp. 244-250; also, *Treatise on Rocks, Rock-weathering and Soils.*

TIN.

THERE was no production of tin from ore in the United States during 1900. Some prospecting was carried on in South Dakota, which resulted in the formation of the Niagara Tin Smelting Co. and the North American Tin Co. to mine and operate in that locality, but nothing definite has been made public as to the value of the deposits. The Niagara company proposes to erect reduction works at Niagara Falls, N. Y. The separation of tin from tinplate scrap was carried out, as in the preceding year, by the Vulcan Metal Refining Co. of Sewaren, N. J. It is stated that about 1·5% Sn is recovered from the ordinary scrap, an electrolytic process being employed similar to that used in Germany and Holland. The de-tinned steel is compressed into blocks by hydraulic pressure and sold to the open-hearth steel manufacturers at about the same price that is paid for the tin clippings.

The combination of tinplate manufacturers known as the American Tin Plate Co., absorbed the plant of the Champion Iron & Steel Co., at Muskegon, Mich., consisting of eight tinplate mills together with an open-hearth steel plant and a bar mill. This was the largest independent plant in the country, and there are now not more than 15 mills outside of the combination.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1895.....	54,252,045	$7,405,619	1897.....	55,172,571	$7,415,933	1899.....	71,248,407	$16,746,117
1896.....	44,639,324	5,848,933	1898.....	62,748,399	8,770,221	1900.....	69,068,568	19,458,586

THE PRINCIPAL TIN SUPPLIES OF THE WORLD. (a) (IN LONG TONS.)

	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
English production.....	8,837	8,328	6,648	4,837	4,453	4,648	4,013	4,100
Straits shipments to Europe and America...	39,670	45,640	47,840	47,180	41,700	43,350	44,460	46,070
Australian shipments to Europe and America	5,579	5,824	4,992	4,320	3,466	2,420	3,337	3,178
Banka sales in Holland.....	5,244	5,626	6,221	6,735	8,900	9,038	9,066	11,820
Sales of Singkep in Holland.....	*Nil.*	261	644	839	800	*Nil.*	*Nil.*	*Nil.*
Billiton sales in Java and Holland.....	5,462	4,735	4,539	5,040	5,100	5,342	5,057	5,820
Bolivian arrivals on Continent.....				210	1,208	1,000	813	1,900
Bolivian arrivals in England.....	2,909	3,482	4,097	3,829	4,298	3,464	3,940	5,037
Straits shipments to India and China.....	4,285	4,655	4,674	6,118	3,214	2,551	1,484	877
Totals in long tons.....	71,986	78,551	79,655	79,108	73,139	71,763	72,557	78 802
Totals in metric tons.....	73,138	79,808	80,930	80,374	74,309	72,911	73,718	80,063

(a) This table is based on the statistics compiled by William Sargant & Co., but the figures of English production are taken from the British blue-book, except for 1899, where Sargant's have been used. The Straits shipments to India and China are as reported by Messrs. Boustead & Co. This table does not include the production of Germany, Austria, Spain, Portugal, and various other countries.

PRODUCTION OF TIN IN THE WORLD. (*n*)

Year.	Australia. (*a*)			Austria. (*b*)			Banka and Billiton. (*c*)	Bolivia. (*d*)	England. (*e*)			Germany. (*f*)		
	Met. Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.	Metric Tons.	Metric Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.
1895..	2,235	$680,400	$304	60	$24,257	$404	10,932	4,166	6,755	$2,233,900	$331	884	$266,292	$301
1896..	1,737	496,060	286	54	18,260	341	11,963	4,104	4,915	1,538,390	313	826	238,017	288
1897..	1,159	350,640	303	48	16,806	350	14,224	5,594	4,524	1,456,680	322	929	287,829	310
1898..	908	302,825	333	48	19,074	397	14,610	4,535	4,722	1,729,060	366	993	372,252	375
1899..	835	490,690	587	41	24,639	601	17,922	4,829	4,077	2,540,470	623	1,481	870,750	590

Year.	Japan. (*g*)	Mexico. (*h*)	Portugal. (*i*)	Russia. (*j*)			Singkep. (*k*)	Straits Settlements. (*l*)	Tasmania. (*m*)			Total Met. Tons.
	Met. Tons	Met. Tons.	Met. Tons.	Met. Tons.	Value (*o*)	Per M Ton.	Met. Tons.	Met. Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	
1895.....	48	39	3	21	$5,068	$241	654	53,354	4,265	$1,301,350	$305	83,416
1896.....	50	5	6	2	476	238	852	53,964	4,759	1,327,369	290	83,237
1897.....	47	1	1	2	476	238	813	45,632	3,484	749,970	302	75,409
1898.....	37	*Nil.*	*Nil.*	(*p*)	(*p*)	(*p*)	685	46,635	2,038	705,810	346	75,211
1899.....	18	*Nil.*	*Nil.*	(*p*)	(*p*)	(*p*)	678	46,679	2,275	1,355,433	596	78,835

(*a*) From *Report of Secretary of Mines and Agriculture of New South Wales*, which is the only Australian colony that produces metallic tin. Tin ore is also exported from New South Wales. Tin ore is produced in Victoria, Queensland, South Australia, and Western Australia, but its metal contents are reported in the productions of other countries.

(*b*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.* The tin production of Austria is derived partly from domestic ores, and partly from Bolivian ores and impure tin from the East imported for refining.

(*c*) Total sales in Holland and Java as reported by William Sargant & Co.

(*d*) Exports of tin and tin in ore from Bolivia to England and the Continent. Some of this tin may be produced in Peru. It is all exported through Peruvian and Chilean ports.

(*e*) From *Mineral Statistics of the United Kingdom.* These figures give the amount of tin estimated to be obtainable in smelting the ore of domestic production. They differ considerably from the figures used by William Sargant & Co., which are possibly obtained directly from the smelters.

(*f*) From *Vierteljahrs und Monatshefte zur Statistik des Deutschen Reichs.* By far the larger part of this production is from Bolivian ores.

(*g*) From the *Resume Statisque de l'Empire du Japon.*

(*h*) According to export returns. Small amounts produced by natives for domestic consumption are not included.

(*i*) From official returns furnished by the Portuguese Government. The figures for 1895–1896 include tin ore.

(*j*) From Russian official reports.

(*k*) The figures represent sales in Holland, reported by De Mouchy & Havelaar and W. Sargant & Co.

(*l*) Shipments from the Straits to Europe and America, as reported by William Sargant & Co., and to India and China by Boustead & Co., except the figure for 1896, which is taken from the *Report of the Governor of the Straits Settlements.*

(*m*) From *Report of the Secretary of Mines.*

(*n*) It will be observed that this table differs from the statistics usually referred to for the world's production of tin, namely, those of William Sargant & Co., and of the *Metallurgischegesellschaft Frankfurt-am-Main.* This is because (1) they reckon Australian shipments to Europe and America, instead of the Australian production, whereby a good deal of Australian tin consumed at home is not included; (2) shipments from the Straits to India and China and the production of several minor countries are not included. A small amount of tin produced in Spain is necessarily omitted, owing to the absence of statistics for that country.

(*o*) In cases where the statistics in the above table have been taken from official sources, wherein values of product have been stated, a calculation of unit values has been made. This developed some amazing differences, which are undoubtedly due to making value calculations at different stages of the product; *i.e.*, more or less cost of carriage is included.

(*p*) Statistics not yet published.

AUSTRALASIA.—*New South Wales.*—The tin production of this State from 1872 to 1899 inclusive has amounted in value to £6,390,484. The value of the output increased rapidly until 1881, when £568,795 was obtained, but it fell off continually thereafter until 1898, when it was £60,565. This decline was due to unfavorable conditions of drought and low prices together with the exhaustion of the shallow deposits of stream tin. The value of the deep deposits and the lodes, however, has scarcely been touched, and it is believed that deep channels and lodes exist in many places beneath a covering of basalt. The principal

lode mine is the Ottery in the Emmaville district, the deposit being of great width but low percentage. By systematic and economical working a profit can be obtained from the ore.

STOCKS OF TIN IN ENGLAND, AMERICA AND HOLLAND. (*a*) (IN LONG TONS.)

	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Stocks, December 31—							
Stock of foreign in London	8,985	13,539	18,097	15,146	8,110	5,486	4,286
Foreign landing in London	1,189	1,025	1,174	673	165	1,212	1,297
Straits afloat for London, including wire advices	3,778	2,825	2,792	2,500	1,050	2,900	3,835
Australian afloat for London, including wire advices	650	825	525	600	400	450	350
Banka on warrants in Holland	1,006	1,154	1,616	2,877	2,228	1,160	837
Billiton in Holland	1,632	1,507	1,638	1,328	1,036	470	330
Billiton afloat for Holland	1,129	1,097	1,742	1,193	1,322	1,050	350
Straits stock in Holland	767	277	789	377	454	100	60
Straits afloat for Holland			950	100	215		
Straits afloat for Continent			650	600	560	450	590
Bolivian in Liverpool	494	492	250	710	300	550	495
Total stocks	19,630	22,741	30,223	26,104	15,840	13,828	12,430
Estimated stock in America and quantity floating	3,820	6,823	3,925	4,500	4,300	2,500	2,600
Grand totals	23,450	29,564	34,148	30,604	20,140	16,328	15,030
Trading Co.'s res'v's of unsold Banka stock in Holland	5,770	6,140	5,953	4,333	3,213	4,353	5,347

(*a*) From the annual metal circular of William Sargant & Sons.

CONSUMPTION OF TIN IN ENGLAND, AMERICA AND HOLLAND. (*a*) (IN LONG TONS.)

	1895.	1896.	1897.	1898.	1899.	1900.
Consumption—						
Deliveries from London after deducting all shipments to America	17,222	19,015	17,118	15,472	13,519	16,061
Deliveries from Holland after deducting exports to London and America	9,029	10,150	11,680	12,130	13,094	14,416
English consumed at home	988	5,000	4,400	4,600	4,400	3,500
Exports of English, minus quantity shipped to America	5,530					
American consumption of all sorts	22,500	29,500	22,500	28,500	31,500	31,100
Billiton sent to other ports than Holland	1,532	1,603	1,370	2,120	1,930	2,400
Straits direct to Continent, less re-exports to America and England	7,622	11,400	9,170	12,740	6,470	5,400
Bolivian delivered from Liverpool	4,099	4,071	3,838	3,874	3,690	5,092
Bolivian delivered from Continent		210	1,208	1,000	813	1,900
Totals	68,522	71,949	71,284	80,436	75,416	79,869

(*a*) From the annual metal circular of William Sargant & Sons.

Queensland.—Considerable development was done in the workings of the older mines and in the construction of roads, railways, reservoirs and sluices. The Herberton district was the largest producer during 1899, the output being 1,030 tons of ore with an estimated value of £58,058. Irvinebank was the center of the production and about one-half of the ore was smelted at the works of the Irvinebank Co. There has been a general resumption of work in many of the lode mines. Recent discoveries on the Kangaroo Hills resulted in the installation of a tin dressing plant by the Waverly Tin Mines Co. of Melbourne. The Stanhope Proprietary Tin Dredging Co. controls 1,000 acres of tin country at Stanhope on the New South Wales border, including the well-known Brisbane and Quart Pot Creek claims. Although the former was extensively worked several years ago it is said that a great quantity of tin still remains. The company contemplates dredging the ground, the conditions being particularly well adapted for this purpose.

South Australia.—A discovery of tin ore near Erea Dam in a quartz vein was reported and, according to Mr. H. L. Y. Brown, the Government Geologist, the

result of assays warrants systematic prospecting for both alluvial and lode tin.

Tasmania.—This State is the largest producer of tin in Australasia, the output in 1899 amounting to 3,281 long tons of ore, valued at £270,864. A large part of the ore is obtained from alluvial deposits, and the lodes, except at the Mount Bischoff mine, have received little attention. There are large areas of ground in the eastern and northeastern sections, which with a plentiful supply of water would add greatly to the output. During the year 1900 the Anchor Tin Mine, Ltd., completed its smelting works at St. Helen's, and the furnaces were started in the latter part of September. The supply of ore is obtained from the company's mine and from various small mines in the vicinity. Operations were greatly hindered the early part of the year by the continued drought. The Briseis Tin Mines, Ltd., at Derby, continued work in its mines, shipping, it is said, sufficient ore to pay working expenses. Surveys have been made to provide an additional supply of water from the Ringarooma River, and it is proposed to develop the mines extensively. A tunnel 800 ft. long for sluicing the wash dirt is being constructed from the workings to the Cascade River. Two dredging companies commenced operations on the Ringarooma River and met with encouraging results. Dredging claims have also been taken up along the foreshore at St. Helen's Point and George's Bay.

The Mt. Bischoff Tin Mining Co. during the six months ending December 31, 1900, smelted 1,446 long tons of ore, yielding 1,028 tons of tin. Of this, 907 tons ore yielding 647 tons tin were smelted on account of the company. The accounts at the end of the year showed a profit of $215,808, after distributing $284,895 in dividends and writing off $46,194 for depreciation of plant, income tax and damages recovered in courts of law. The earnings during the six months exclusive of interest were $302,542. According to the general manager's report, the total mining cost per ton of 2,240 lb. was $1,522, divided as follows: Mining, including new works, maintenance and other expenses, 67c.; hauling, filling and emptying trucks, 9·75c.; crushing, dressing and maintenance of plant, 19·67c.; slime sheds, 2·17c.; ring tail sheds, 5·2c.; management and supervision, 13·2c.; plant, including all machinery, 8·17c.; development and progressive work, 7·4c.; waterworks, 0·17c.; ore bagging, 1·17c.; sundries, 7c.; stores, 10·25c. The amount of ore obtained from the mines from the date of formation of the company to the close of the year 1900 was 58,307 long tons.

Western Australia.—Mining operations have been most active lately at Greenbushes in the southwestern part of the State, but some ore was mined also in the Kimberley district and around Pilbarra. The Greenbushes tin field, which was discovered in 1890, is situated on the tableland drained by the headwaters of the Norilup and Hester's Brook. The surface of this tableland is hilly and broken, gradually opening out into large flats toward the southwest. Geologically it consists of gneissic and granitic rocks intersected by dikes of diorite and tourmaline granite with overlying conglomerate and alluvial deposits. The granite contains cassiterite, tourmaline, zircon, garnet and other minerals as accessory constituents. Specimens of the rock from the Cornwall mine assayed 1.79% Sn. The dikes also carry tin ore in some quantities, it being a component of the tourmaline. As a result of numerous investigations it has been found

that the ore bodies are a network of irregular tin bearing veins, which are distributed over a fairly well defined area. Some difficulty is experienced in concentrating the ore, as the cassiterite is accompanied by a mineral of nearly the same specific gravity, which, according to the Government Analyst of South Australia, contains about 51% Ta_2O_5, 8% Nb_2O_5 and 40% Sb_2O_3, and small quantities of Bi_2O_3 and NiO. The quantity of ore exported from the Greenbushes field in 1899 was 278 long tons, valued at £28,138, while in the first ten months of 1900 the exports of tin and ore amounted to 377 long tons. Some of the best properties, including the Cornwall, Bonanza, Peterson's and Mount Pleasant, have been secured by the West Australian Tin Syndicate, Ltd., which obtained a Government concession to pump water from the Blackwood River 4 miles distant from the center of the field. This company also owns a local smelting works which treated about 400 tons of ore in the past year. With a constant supply of water the output of the district could be largely increased. The Marble Bar Tinfield, Pilbarra, began development in 1899, and at the close of the year 42 leases, embracing 1,181 acres, were taken up, of which 1,059 were being operated. In addition, a large number of men were working alluvial claims. While the production of but 57·5 tons were reported in 1899, the amount of development work was large, and an increased yield is prophesied for 1900.

Bolivia.—Tin ore is mined in the Departments of Oruro, Potosi, La Paz and Cochabamba. The Department of Oruro is much the most important, containing within its borders 25 mines out of a total of 37 for the entire country. The largest mine is at Huanuni and it is also the most favorably situated as regards transportation. Owing to the lack of capital and facilities of transport the industry is but little developed and it is stated on good authority that the product could be easily doubled under more favorable conditions.

Burma.—A company is being formed to work deposits in the Maliwan township of the Mergui district, which will use the most approved methods. These deposits were exploited some years ago, but no profit could be obtained at the prices of tin which ruled at that time.

Java.—The exports of tin from Java and Madura in long tons are reported as follows:

	1894.	1895.	1896.	1897.	1898.	1899.
Private	5,768	4,526	4,825	5,436	5,194	5,248
Government	6,789	6,950	6,707	8,137	8,934	11,359

Malay Peninsula.—While river dredging for tin has not yet been seriously attempted, applications for water rights to follow this method of mining are being made. Roughly estimated the Pahang waterways extend 1,000 miles, and dredging enterprises would greatly benefit this State. According to the conditions imposed by the Government, each lease will comprise ten miles of river and will run for a period of ten years, with privilege of renewal if *bona-fide* work has been done. The premium is £20 a mile with an annual quit rent of £10. A stipulation provides that machinery of at least £5,000 in value must

be brought in. Some progress has been made lately in the development of lodes, especially in the district of Kuantan, Pahang. It is stated that 2,500 tons of rock are being treated per month for a yield of 85 to 95 tons of tin oxide, an average of about 3·5% per ton. The standard to which the oxide is dressed exceeds 70% of metal, among the impurities being iron oxide, silica and small amounts of copper. It is confidently expected that the next few years will show a marked increase in the output of tin from this source. With the benefit of past experience, future undertakings should undergo more rapid development and there should be a considerable reduction in working expenses which will enable low-grade ores to be treated at a profit. The geology of the district is similar to that of parts of Cornwall, consisting of granite as basal rock with overlying schists. The tin lodes extend through both formations and range in thickness from 2 to 10 ft. Their strike is usually about east and west and their dip inclines 10 to 40° from the vertical. Reference should be made to the separate article on "The Tin Industry in the Malay Peninsula," by Frank Owen, later in this section.

Russia.—The occurrence of tin ore in the Province of Transbaikal near the river Onon in eastern Siberia has been known for a great number of years, but the deposits have received as yet little attention. Recent discoveries have been made near the settlement of Olowjanny Rodnjik on the left borders of the Onon, near the village of Nishung Scharanai on the right bank of the Onon and at the settlement of Sawitinski on the same side of the river. The deposits are situated near the Siberian railway and the conditions of water supply and fuel are favorable.

United Kingdom.—The Dolcoath Mine, Ltd., during the first half of the year 1900, earned a net profit of £32,414 against £31,066 for the preceding semester. The average recovery from the ore was 51·8 lb. as compared with 56 lb. for the previous half year. No new shares were issued and the company still holds 26,617 shares in reserve. More extensive development work was carried on than at any period in the history of the company, resulting in a large quantity of tin ground being laid open. The manager states that the prospects of the mine are better than for a long time past as the exploration shows extended areas of tin ground carrying moderate value, although there are no rich bunches as were formerly found. Forty additional Frue vanners, making 77 in all, were installed and gave satisfactory results. Two dividends amounting to £19,213 were paid, leaving a surplus of £11,565 after writing off £12,031. The statistics of production since the formation of the company are given in the following table:

Six Months.	Tin Ore Crushed.	Black Tin Sold.	Produce per Ton of Ore.	Average Value per Ton of Ore.	Average Price per Ton of Black Tin.	Amount Realized.
	Tons.	T. c. q. lb.	Lb.	£ s. d.	£ s. d.	£ s. d.
December 31, 1895	28,717	1,015 5 1 16	79·19	1 7 8·36	39 3 5	39,769 2 5
June 30, 1896	30,015	1,029 19 1 10	76·86	1 5 6·33	37 4 0	38,311 6 5
December 31, 1896	33,712	1,009 7 0 25	67.08	1 1 10·20	36 9 2	36,830 18 2
June 30, 1897	35,879	1,021 17 0 22	63·79	1 1 7·27	37 18 7	38,760 7 2
December 31, 1897	37,686	1,073 2 1 9	63·78	1 1 6·78	37 17 4	40,636 19 8
June 30, 1898	38,089	1,140 7 2 22	67·07	1 3 8·94	39 16 4	45,221 15 1
December 31, 1898	40,608	1,162 0 0 0	64·10	1 6 10·09	46 18 0	54,497 6 3
June 30, 1899	41,101	1,037 19 1 23	56·57	1 13 8·21	66 12 7	69,222 12 0
December31, 1899	41,639	1,040 18 1 10	56·00	1 19 8·39	79 7 11	82,651 16 0
June 30, 1900	45,102	1,043 9 0 0	51·80	1 28 3·57	82 15 4	86,364 18 10
December 31, 1900	43,254	960 19 1 21	49·76	1 15 11·4	80 18 2	77,750 14 4

A new tin mine is being developed in the St. Austell district on a lode which is said to average about 2% black tin.

EXPORTS OF TIN PLATES FROM THE UNITED KINGDOM.

(In tons of 2,246 lb.)

	1894.	1895.	1896.	1897.	1898.	1899.	1900.
To the United States.....	226,880	222,901	113,049	85,472	65,337	63,547	58,040
To other countries.....	127,048	143,081	153,914	185,758	186,432	193,082	215,915
Totals.....	353,928	365,982	266,963	271,230	251,769	256,629	273,955

The Tin Markets in 1900.

New York.—In our review of a year ago in which we expressed the opinion that 1899 would long be a memorable year in the history of the tin market, we rather anticipated that 1900 would not prove so interesting. However, such has not been the case, and while we cannot chronicle so continuous an upward movement, the wide fluctuations and the excitement and heavy speculations that ruled in the tin market during the past year will long make it remembered.

The average price of tin at New York for 1899 was about 25c.; for 1900 it has been about 30c. The highest price reached in 1899 was about 32·75c., and in 1900 the market went as high as 34·5c.

Consumption in this country has increased. Supplies continue to be drawn principally from the East Indies both by direct shipment and via London. The latter point continues to be the center of the world's market; and while at frequent periods the American market did not closely follow the gyrations of the London market, and it sometimes happened that tin was selling here at considerably above the London parity and again at considerably below, still the general course of the market was established in London. We must, therefore, keep the London market well in view in reporting the New York tin market for 1900.

The year opened here with spot tin selling at 25c. and February delivery at a discount of 0·5c to 1c. The London market opened at £110. The market fluctuated a great deal, but always with an upward tendency, and early in February £130 was reached. Meanwhile, there was a heavy discount for three months' tin; at one time it was £3 per ton.

During February the market advanced to 30·5c. The London market went as high as £153, and a large business was done. Meanwhile, an enormous backwardation had ruled, frequently as much as £10. The upward movement was mainly speculative, being an anticipation on the part of large operators of a scarcity in consequence of the large demand from America and the apparent short supply at the Straits.

In March the market continued very strong and prices went higher, spot tin selling at 25·5c. At these prices, however, consumers generally held off and business for a time was restricted to spot tin. Toward the middle of the month the London market broke to £138 and the New York market followed suit, spot tin selling down to 31c. The sharp break was chiefly caused by the announcement on the part of the Netherland Trading Co. that at their sales during the

second half of 1900 an extra 2,000 tons of tin would be offered. Meanwhile, the statistical position of the article continued to be very strong. Shipments for the first quarter of the year were 1,000 tons less than in 1899, and deliveries both in Europe and America showed an increase.

In April the market was quiet, consumers pursuing a hand-to-mouth policy. Prices fluctuated but little until the end of the month, when a decline took place to 29·5c.

During May a large business was done at about the same figure. The London market fluctuated constantly, but within comparatively narrow limits.

In June the London market moved wildly. Speculators had sold short for June delivery and the market was pushed up from £133 to £148. Toward the end of the month it fell again to £138 and closed on the 29th at £146; then, the shorts having covered, the upward movement was stopped. The statistical position of the metal continued to be good, but a heavy backwardation for future deliveries appeared to indicate a lack of confidence in the maintenance of the high prices ruling. The New York market did not closely follow the fluctuations in London, stocks on this side being much larger, with no short interest to be squeezed. The prices during the month ruled about 29·5@30·5c. until the end of the month, when stocks of spot tin being exhausted, early deliveries sold at 32c.

During July our market was extremely active and a large business was done both for early and distant deliveries. Spot tin sold as high as 34·5c., and it was only toward the end of the month that larger arrivals relieved the situation. The American buying influenced the London market, which rose from £139 to £144.

During August a heavy decline of £10 took place in consequence of the decrease in the American demand, owing to the idleness of the tinplate mills, which had been shut down early in July. During the month there were rumors that they had started up again, and this affected prices somewhat. However, these proved to be premature, and the American market was dull and weak, spot tin selling down to 30c. The same conditions prevailed during the first half of September, and then, in sympathy with a heavy drop in London, the market declined to 28·25c. The cause of the decline was principally to be found in the announcement that the Banka sales for 1901 would be increased to the extent of 25%.

In October the market dropped considerably, selling down to 25·75c., but at the lower figures consumers generally took hold, and during November the volume of business was very heavy; toward the end of the month an advance set in to 29c. However, early in December the London market experienced a violent slump, and while on this side spot tin held comparatively firm, in consequence of the short supplies, later deliveries sold down. Spot metal sold at 26·5c., and 26c. was accepted for January delivery.

At the close of the year heavy purchases for American account changed the tone of the market and an advance took place both in London and New York, 28·25c. being paid for spot delivery and futures selling at 27·5c. Heavy arrivals on this side, however, again brought the price down, and closed the year with spot tin selling at 27c., while 26·75c. is quoted for futures.

AVERAGE MONTHLY PRICES OF TIN IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1896	13·02	13·44	13·30	13·34	13·54	13·59	13·63	13·49	13·15	12·94	13·09	12·96	13·29
1897	13·44	13·59	13·43	13·34	13·44	13·77	13·89	13·80	13·98	13·88	13·79	13·71	13·67
1898	13·87	14·08	14·38	14·60	14·52	15·22	15·60	16·23	16·03	17·42	18·20	18·30	15·70
1899	22·48	24·20	23·82	24·98	25·76	25·85	29·63	31·53	32·74	31·99	28·51	25·88	25·12
1900	27·07	30·58	32·90	30·90	29·37	30·50	33·10	31·28	29·42	28·54	28·25	26·94	29·90

London.—The year opened with the total stock in England and the Continent at 13,487 tons, and the price was £117, cash, and £118, three months. America and the Continent sent large orders, but these were counteracted by free offerings from the Straits, and prices were driven down to £108 5s. for cash. America, however, at this time was very short of spot material, and this caused prices to rise rapidly until cash touched £130 10s., three months at the same time selling at £125, and these figures were about the closing ones for the month.

February showed a decrease in statistics to 12,798 tons, cash and three months' prices being about £130 and £125 respectively. Holders, however, at this time began to realize, which caused a decline to £128 5s. for cash and £125 10s. for three months; but America was still buying, and the Straits were not offering freely, so that before the middle of the month was reached cash was fetching £147 10s. and three months £140. Cash tin at this period was very scarce in London, owing to the available supplies being in the hands of a few operators, and to the fact that large quantities which had arrived in the Thames could not be discharged, owing to labor troubles. At this point a steady decline set in, owing to the free selling of forward metal by American operators and realizations of speculative holdings, values declining to £143 10s., cash, and £133 15s., three months.

Statistics published at the end of February showed a further decrease, and the total supply of England and the Continent only amounted to 11,592 tons, and during the second week of March the record price of £153 was paid for large quantities of cash metal by the bears who wanted to square their positions, three months at the same time realizing only £145 10s. After these high figures had been paid the leading bull operators let go a large line of cash metal, which caused a rapid shrinkage in value, and as low as £139 was accepted for cash, three months selling at £135 15s. The free offerings of cash metal caused the backwardation—which had lasted for some months—almost to disappear, and values tumbled to £133, spot, and £131, forward. The decline, however, seemed to have been too rapid, and values were soon again run until, at the end of the month, the market closed at about £140 for cash, forward selling at about 10s. less.

Statistics published at the beginning of April showed an increase of about 1,500 tons, and this caused holders to realize and tempted bears to sell, so that values once more declined until £134 15s. was accepted for cash and £133 10s., for three months. Values in the East were stiffer and American operators were purchasing both Straits and Banka, causing a better tone to be shown, and cash improved to £140 5s. and three months to £139 5s., but toward the end of the

month the market again took a downward course and prices fell to £135 5s., cash, and £135 2s. 6d., three months.

May opened with very favorable statistics, showing 3,000 tons decrease for the previous month, and leaving the visible supply of England and the Continent at 9,938 tons. Cash at one time touched £137 15s. and three months £1 below these figures; but there was then a pause, values declining to £131, cash and £130 10s., three months, and after several fluctuations the month closed at about £134, spot.

June statistics showed an increase of over 1,500 tons, but the scarcity of cash warrants prevented sellers from unduly depressing prices. The tinplate industry was rather disturbed, owing to the threatened strike of workers in South Wales and America, and this, together with the weakness that was apparent in nearly all branches of trade had a bad effect, causing values to decline to £136 10s., spot, and £127, three months, but notwithstanding the cheap offers of forward stuff which came from the Straits, the bulls were able to drive the price of cash up to £148 for June deliveries, while three months only improved to £131. When the bulk of those short had adjusted their prompts the heavy backwardation on forward metal was reduced and the month closed with a strong market at £145 10s., cash, and £134 5s., three months.

July figures gave another increase in the English and Continental stock of about 1,500 tons, and at the opening cash metal sold at £147, but the biggest holders released large quantities, and this gave rather more confidence to sellers, so that prices suffered and dropped to £138 5s., spot, and £132, forward. Consumption remained good and America was buying freely, which again improved prices to £145 10s., cash, and £140, three months, but the month closed rather lower at £144 and £138 15s., respectively.

There was again an increase in the figures published at the beginning of August, which caused dealers to accept lower prices, but there was a continued good demand from consumers, and the market soon rallied, remaining fairly steady throughout the first three weeks of the month in the region of £143 10s. for cash. The market then began to fluctuate violently and prices were driven down to £134 15s., spot, and £132 5s., three months, eventually closing better at £136 15s. and £135 10s. for these positions.

September commenced with the total stock of England and Continent standing at 12,053 tons, which was an increase of only 71 tons, compared with the previous month, and the cash price was £138 10s., three months being worth £135 10s., then declining to £134 15s. and £132 5s., at which level there was some good buying from America, caused by the restarting of the American tinplate trust mills, and cash touched £136 15s., three months, £134 10s. It was at this time that the Dutch Government announced its intention to sell during 1901 about 2,000 tons more Banka than it was doing in the present year, and this caused values to rattle down to £125, cash, £124, three months, but a strong speculative movement then set in, and before the month was over we had a recovery to £133, cash, and £126 10s., three months.

The total stock of England and the Continent published at the beginning of October was 12,802 tons, being an increase on the previous month of about

750 tons, but the bull clique forced the price up to £135, cash, and £130, three months. Owing to rather free selling of the East and the cessation of speculative buying, prices dropped to £128, cash, and £124 10s., three months, closing at about these figures.

November statistics showed a decrease in stocks of about 1,230 tons and cash tin was very plentiful, owing to the lightermen's strike, which prevented deliveries being made from warehouse. After the market opening at about £128 for cash and £125 2s. 6d., three months, values eased off until £124 2s. 6d. and £121 15s. was accepted for cash and three months respectively. America at this time was taking fair quantities and the consumers on this side were also buying against tinplate orders, and these purchases caused values to improve to about £129, cash and £128, three months.

At the beginning of December there was a determined onslaught made on the market by the bears, who sold large lines of forward metal, which, however, was readily absorbed by the operators for the rise, causing a decline to £123 15s., cash, and three months. The visible supply at the commencement of this month amounted to 14,154 tons. The tendency, however, was weak, and after several small improvements prices drifted very gradually until they touched £113.

At the close of the year the market showed a somewhat firmer tendency, and closed at £121 10s. for both spot and futures.

Progress in Technology of Tin in 1900.

Metallurgy.—George J. Latta, manager of the Mount Bischoff tin smelting works at Launceston, Tasmania,* describes the smelting of tin ores. The product of the Mount Bischoff mine is remarkably pure, free from every impurity except iron, and its admixture with ores from alluvial sources rich in silica gives an advantageous smelting charge, the iron and silica combining with each other to form a slag. The usual charge consists of 5,000 lb. of various ores intermixed with 1,000 lb. of small coal which is thrown on to the hot hearth of a reverberatory furnace; the doors being closed during the operation in order to keep the atmosphere of the furnace reducing. The charge is rabbled frequently and is completely reduced at the end of eight hours. The molten metal collects on the hearth of the furnace and the lighter slag, containing the impurities, floats on top. The metal is tapped into a brick-lined vessel and the slag skimmed off for further treatment. The furnace is emptied, another charge is thrown in, and the operation repeated. The molten metal is ladled to a large kettle and refined by introducing billets of green wood below the surface. The agitation of the metal due to the steam formed from the moisture contained in the wood aids to oxidize the impurities which collect as a dross and float on the surface. When the tests show that the metal has been sufficiently refined it is cast into 75-lb. ingots for shipment to England, smaller sizes being cast for local consumption. The refined metal contains 99·8% Sn. The slags and furnace workings are mixed with small coal and lime and again smelted, yielding a metal very impure from the large amount of iron present. The iron impurity is eliminated by

* *Report of the Secretary for Mines of Tasmania*, 1899-1900.

smelting the metal with the next charge of ore. Ores containing arsenic and copper, and sometimes lead, antimony and zinc, are treated separately. Arsenic must be removed by dead roasting the ore before treatment, otherwise it will harden the resultant tin and, when once alloyed, there is no practical means of removing it. The Mount Bischoff smelting works treats custom ores as well as the product of the company's mine, and to cover smelting losses certain deductions are made. For ores of 70% tin content or over 2% is allowed and for ores of lower grade, the percentage of reduction is greater as the smelting losses increase rapidly as the ores become poorer.

Tinning.—The tinning process as applied to malleable iron, wrought iron and steel has been described in a general manner by W. T. Flanders in a small book entitled *Galvanizing and Tinning,* 1900. The plan of arrangement of works, preparation of articles by removing scale and rust with sulphuric acid, tinning and re-tinning operations are discussed in brief outline.

Effect of Tin on Canned Meats.—In examining meats preserved in cans for the occurrence of tin, F. Wirthle* found that the white crust sometimes formed was basic tin chloride resulting from the action of the salt on the tinned surface, either by direct action on the tin or by forming first an organic salt of tin which was subsequently converted into a basic sodium stannous chloride and an organic sodium salt. A number of tin determinations were made of canned meats and the maximum per cent. of tin obtained was 0·014 in a can of beef five years old. The interiors of the cans were corroded almost exclusively in places that had been in contact with the fat and never where the contact was with gelatin.

Chemical Analysis.—An extremely delicate qualitative test for tin consists in the addition of a stannous chloride solution to one of ammonium molybdate as usually prepared. A blue tint is thereby imparted to the mixture even in the presence of 0·0000042 g. of stannous chloride per cubic centimeter of solution.

Electrolytic Deposition.—E. Quintaine, of Argenteuil, France, has obtained a patent† for producing a perfect electrolytic deposit of pure tin by the use of a bath of stannic salt dissolved in the presence of an ammonium salt. The current density should be weaker than that employed for copper, otherwise the deposit will be irregular.

A Review of the Tin Industry of the Malay Peninsula (up to the end of 1899).

By Frank Owen.

It is almost a commonplace to say that the metal tin has now become a daily indispensable adjunct of modern civilization in all parts of the globe. One has only to reflect on its universal use in the form of tin plate for utensils of culinary and other domestic use, to observe what a truly enormous part tin plays in the daily life of every household. Again, as a receptacle for the air-tight preservation of meats, fruits, vegetables, and almost every other kind of food, this metal enables the traveler—be he explorer, prospector, or miner—to

* *Chemiker Zeitung,* March 28, 1900.

† English Patent, 5,496, March 23, 1900.

penetrate into uninhabited regions, where he would be otherwise entirely without means of subsistence. Thus, the question of the world's principal sources of tin supply as affecting the price of the metal is a matter of no small interest and importance.

No metal of equal commercial importance has of late years seen such wide fluctuations in price. Within the five years 1895-1900 refined tin has varied in London from £55 to £150 per ton (2,240 lb.).

The Federated Malay States comprise Perak, Selangor, and the Negri Sembilan on the west coast, and Pahang on the east coast of the Malay Peninsula. Locally they are usually known as the "Native States," and elsewhere under the generic but, strictly speaking, incorrect term of the "Straits Settlements."

These States are each under the nominal rule of its Sultan, who legislates acting on the "advice" of the British Resident, who is appointed by the Colonial Office. From 1874, when they first came within the sphere of British influence, until 1897, each of these States legislated independently of the other, but on the occasion of Her Majesty's Diamond Jubilee, they became federated, benefiting thereby to the extent of uniformity of legislature, and assimilation in the methods of government, under a federal chief in the Resident General. The Federated Malay States are indeed comparable on a smaller scale to Egypt as regards successful administration.

The control of mining affairs and the administration of the mining enactments in each State are in the hands of a Warden of Mines, who is appointed by the British Resident, and is assisted by qualified European Inspectors of Mines, and native overseers. The Warden of Mines has very full powers, and is a magistrate of the first class, subject in certain cases, to appeal to the higher courts. His duties may be briefly defined as settling disputes between lessees of mining lands, and sitting in the Warden's Court to decide on all civil and criminal cases which relate to mining. By means of these courts, civil mining cases are promptly heard and settled, either in court or at the mine itself, to the benefit of all classes of mining litigants. In the ordinary courts of law of the Federated Malay States, barristers are allowed to practice, but they may not be heard in the Warden's Court. This necessarily makes litigation much cheaper, and it is a matter of opinion whether it is beneficial or otherwise for litigants. Under the new system in 1897 official mining reports were first regularly published, though for some years prior to that date statistics of the industry were tabulated in the different States.

The Occurrence of Tin Ore.—The tin ore in the Malay States is found entirely in the form of cassiterite or tin oxide. It runs, roughly speaking, from 68 to 77% metallic tin. The average percentage is about 70, the theoretical being 78·2. Tin ore has been found at Bentong, in Pahang, that yielded by assay 77% of metal. Tin ore occurs in the alluvial fields, in the form of the finest dust up to lumps several hundred pounds in weight. It is found in every conceivable form of soil, from the stiffest of clays to the lightest of sands—from the very grass roots down to depths of 150 ft.—in the lowest valleys, and on the tops of mountains.

The impurities met with, which from their specific gravity to a certain extent


A MAP OF THE
Malay Peninsula.
SCALE OF STATUTE MILES
0 10 20 30 40 50 60
1897.
KNOWN TIN FIELDS
KNOWN GOLD FIELDS
ENGRAVED BY BORMAY & CO., N.Y.
KEDAH
PERAK
SELANGOR
NEGRI SEMBILAN
MALACCA
JOHOR
PAHANG
TRENGANU
KELANTAN
Labang
Kota Sálak
Tanah Mana
Pringanu
Langkor
Thaiping
Port Weld
Port Dickson
Seremban
Kwala Lumpur
Kwala Klang
Batu Barok
Kwala Selangor
Sempang Kadangsa
Bernam
Bukit Changoi
Lumut
Pantai
Batu Gajah
Gopeng
Kinta District
Kota Bharu
Kwala Lipis
Bulu Gajah
Kuantan
Pekan
Kg. Bharu
Kg. Dedadou
K. Bentong
Jelebu
Jumpol
Kwala Pilah
Johol
Sungei Ujong
Rembaw
Naning
Alor Gajah
Malacca Town
Malacca Terr.
Kandang
Panghore
Bandar Maharam
Padang
Rumpin R.
Pulau Bengkalis
P. Rupat or Segaro
SUMATRA
Johor Bharur
SINGAPORE
Singapore Town
Old Str.
Kwala Pahang
Kwala Bernam
Kwala Selangor
Kwala Muar
Johor R.
S. Sembrong
Bagamat
Limestone Caves
Red Round Stone
Yellow Sand Stone
Great Rédang
Perhentian Is.
Kemaman
North Cape
Pulo Bernala
South Cape
Province Wellesley
Krian
Penang
Dindings
Lankawi
Pulo Tarjong
Tongkal Range
Titi Wangsa Range
Gajah Mati R.
Kelantan R.
Trengganu R.
Pahang R.
Perak R.
Selangor R.
Langat R.
Muar R.
Johor R.
Penaruban R.
Sinibauh R.
Canal
Straits of Malacca
China Sea

make the hand dressing of tin ore difficult, are magnetic and titaniferous iron ore (manaccanite), mispickel, iron pyrites, tourmaline, and wolframite. Alluvial gold is often found associated with the tin ore, especially in the Batang Padang district of Perak, but its occurrence with tin is rather a sign of the poverty of the deposit, which fundamentally is probably geologically correct, and to be expected.

It is quite safe to assert that at least nine-tenths of the tin exported from the Malay States comes from alluvial workings. More detailed accounts of the methods of working these deposits have already been described by the author.* Consequently there is no need for enlargement on the subject other than to say that since that time the hydraulic system of mining has obtained a still firmer footing in the Straits, and has proved very profitable as well as being the means of considerably adding to the annual output. The country on the whole being well watered, lends itself with facility to schemes of this kind. On the other hand, through the force of circumstances, the Chinese methods of alluvial tin mining are becoming more scientific, and more in accord with approved Western ideas. Dredging for tin, which has been proposed, especially for working the river beds in Pahang, is still practically in its infancy, but there seems to be no reason why it should not meet with success.

General Geology.—Very little is known of the geology of the Malay Peninsula, and so far, unfortunately, no attempt has been made to map out any of the geological formations. The main mountain ranges are granite; in the foothills and valleys are to be found the outcrops of gneiss, schists, slates, dolomites, mudstones, sandstones, and highly crystalline limestones. With one exception (to be described later) no fossils have been found in any of the geological formations, which would enable the series of rocks to be classified. This may be owing to the fact that either the rocks have been so completely metamorphosed as to obliterate all traces of remains, or else that no systematic search has been made for fossils. Difficulty must stand in the way of any attempt to make a geological survey of the Peninsula, owing to the great depth of alluvium covering the bed rock. The former consists of alternate layers of sand, clay, and gravel, which in depth give way to kaolin. The Chinese miners formerly considered that when a bed of kaolin was reached, it was useless to sink further, and in fact they looked on the kaolin as bed rock. At one time in Perak there was much controversy on this subject, and the Government inspectors of mines, who had been appointed from the Royal School of Mines, London, gave their opinion that it was quite wrong to conclude there was no further tin bearing ground beneath the kaolin. They accordingly advocated the introduction of such regulations as might be necessary to insure the land being prospected and exploited in depth; and in many mines which had been said to have been bottomed, shafts were sunk with magnificent results. As a result the Government formulated measures that insured the mines being properly worked in depth.

The one exception previously mentioned in the non-occurrence of fossils is from Pahang, on the river Lipis. Specimens of this rock have been identified

* *Transactions of the Institution of Mining and Metallurgy*, Vol. VI., 1897.

by Mr. R. Bullen Newton, palæontologist to the British Museum, as Lamellibranch casts impressions, many of them being sufficiently well defined to point conclusively to their Triassic origin. The most abundant gems represented is "myophoria," so characteristic of the Trias period. "Chalamys valoniensis" also occurs together with other bivalves. These fossils are the first recorded from this area of southeastern Asia.

Production and Prices.—What is known commercially as "Straits tin" comes practically entirely from the Federated Malay States, which produce considerably over one-half of the world's output (in 1899 38,353 tons out of a total of 72,557 tons). It is very plain, therefore, what an important factor these States are in regulating the price of the metal. The object of this paper is not so much to give a description of the methods of tin mining as practiced in the East, as a statistical review of the tin output from a commercial standpoint, with a surmise as to the bearing of this on the future production.

It will be seen on reference to the subjoined table of statistics that the output of metallic and "black" tin in the Federated Malay States increased from 26,483 long tons, valued at £2,476,160 in 1889 to 49,128 tons, valued at £3,161,386 in 1895, when the maximum of production was reached. Since that time the output has gradually decreased until in 1899 38,353 tons were produced of a value of £4,579,731.

OUTPUT OF BLOCK TIN FROM THE FEDERATED MALAY STATES DURING THE YEARS 1889-99, WITH APPROXIMATE VALUE OF SAME. (*a*)

States.	1889.		1890.		1891.		1892.		1893.		1894.	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
		£		£		£		£		£		£
Perak	14,027	1,308,319	14,116	1,360,543	14,675	1,372,567	16,538	1,501,473	18,822	1,756,685	23,553	1,658,537
Selangor	10,847	1,017,057	10,389	970,165	11,638	1,080,307	12,390	1,197,503	16,771	1,291,903	20,112	1,346,830
Negri Sembilan	1,312	123,083	2,143	187,080	2,446	224,952	4.185	403,359	3,440	315,495	2,585	202,450
Pahang.....	297	27,701	328	31,444	357	33,567	387	38,290	417	38,479	476	32,631
Total	26,483	2,476,160	26,976	2,549,232	29,116	2,661,393	33,500	3,140,625	39,450	3,402,562	46,726	3,240,441

States.	1895.		1896.		1897.		1898.		1899.	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
		£		£		£		£		£
Perak	23,866	1,529,118	22,811	1,391,710	20,967	1,312,599	19,851	1,418,354	18,960	2,264,013
Selangor	21,854	1,422,217	20,592	1,256,307	17,980	1,125,598	16,991	1,214,007	15,180	1,812,644
Negri Sembilan	2,873	175,801	2,999	182,749	2,916	182,473	2,720	194,344	3,410	407,188
Pahang.....	535	34,700	633	38,369	547	34,196	712	50,872	803	95,886
Total	49,128	3,161,836	47,035	2,869,135	42,410	2,654,866	40,274	2,877,577	38,353	4,579,738

(*a*) The returns from the Negri Sembilan and Pahang for the years 1889-93 and from Pahang for 1894 are approximate only.

Up to November, 1898, the "black tin" was calculated for the purpose of collecting duty as containing 65% of metal, but since then the official rate is 68%. The export duty varies from 12 to 17%, according to the price of tin. The metallic tin shipped represents that smelted in the Native States by the Chinese, and the black tin the ore shipped to the smelting works of the Straits Trading Co., at Pulau Brani, Singapore. Roughly speaking, about three-quarters of the tin is shipped from the Native States as metal.

During the period of increased production 1889-95, the average annual Lon-

don price of Straits tin (which is £3 to £4 per ton lower than that of refined English ingots), fell from £93 10s. 10d. to £64 7s. 2d. per ton. The corresponding decrease in the Singapore price was from $37·60 (Straits) to $32·07 per pikul, (of 133·3 lb. avoirdupois, the unit of weight in the East), the average being $35·20.

At the same time the sterling exchange value of the "Straits" or Mexican dollar (the Japanese "yen" being then also equivalent), dropped from 3s. 5d. to 2s. 1d. in sympathy with the fall in the price of silver. The Straits Settlements proper, and the Protected States being on a silver basis, the Chinese cooly labor is paid entirely in silver. It consequently follows that the price of tin, and therefore the output, are to a great extent—though not entirely (as will be pointed out later)—connected with the fluctuations of the silver market. Thus, in 1891 the London average price of standard silver was 45·06d., in the following year it dropped to 39·81d., while in 1895 we find it down to 29·13d.

For these three years the mean exchange value of the local dollar was 38·37, 33·95, and 25·09d., respectively. As the sterling value of the dollar depends entirely on the price of silver, so the dollar value of tin rose in an inverse ratio with it. Had the price of silver remained the same when tin dropped one-third in value, from £90 to £60 per ton, we should have expected the local price to fall from $37 to $25 per pikul, whereas, owing to the decreased sterling value of the dollar, it only fell to $32 per pikul. On the other hand, we find that the fall in the value of exchange made the various commodities necessary for the laborers (dry goods, etc.), obtained from countries on the gold basis more costly, and thus to some extent it became more expensive to produce tin.

The year 1896 saw the first check to the rapid increase of former years; as compared with 1895 there was a decrease of rather more than 2,000 long tons. The price of foodstuffs during this year was abnormally high. This fact, coupled with the low price of tin ($32·13 per pikul in the Straits, and £60 19s. 2d. in London), undoubtedly tempted many of the Chinese miners to forsake their vocation, and take to some more lucrative form of employment on public roads, railway construction, and coffee estates. The year 1897 began none too rosily for the miner, and although during this year the dollar fell to 1s. 11·75d., the average value of tin rose to $36·08 per pikul, or £62 12s. 9d. per ton. Thus, the enhanced price of tin fully counteracted the drop in silver.

One would have thought that the output would have at least remained stationary, even if it did not show an increase. The result of the year on the contrary, showed a decrease of 4,264 tons as compared with the previous year, and 6,718 tons as compared with 1895. The explanation of this seeming anomaly is that during the years 1889-95 cooly labor was continually coming from China to the Native States to work the tin alluvials. In 1897, on the contrary, although the local price of tin stood actually higher, little or no labor was directly introduced. However, to a limited extent, the rise in the price of tin brought back to the mines those engaged in other pursuits. In this year 116,300 Chinese laborers were employed above and below ground in the tin mines, and 124,709 acres had been "alienated" or taken up for the purposes of mining. The output per miner was approximately 812 lbs. (6·12 pikuls) of tin valued at $220·81 or £21·17.

Dealing with the output of 1898, the chart shows that it nearly agrees with that of 1893, when tin stood at an average price of $37·60 per pikul. The year 1898 opened with tin at a higher price than any recorded during the previous ten years. The local average price of tin rose to $43 per pikul, while exchange remained stationary at about 1s. 11·75d. to the dollar. The London price of Straits tin averaged £71 11s. per ton, yet the output of the year was only 40,274 tons, showing a decrease as compared with 1897 of 2,136 tons and with 1895, of 8,854 tons. And this in spite of the fact that tin was actually standing $5 per pikul higher than in 1893, in which year, as compared with 1892, there was an increase of about 5,000 tons.

Mining Conditions.—The reasons which have been given repeatedly for the decrease in output between 1895 and 1897 are that tin was at a low price, while the price of foodstuffs had increased, and consequently mining did not attract labor. Now, on the contrary, we are told that tin is at such a high price that the laborer need only work short hours to gain a livelihood, yet we still hear the same old complaint as to scarcity of labor. More significant is the fact that in 1898 the amount of land "alienated" for tin mining had risen to 141,037 acres, an increase on the previous year of no less than 16,328 acres.

It is true that tin was at a low price during 1896 and 1897, but not lower than in 1890 and 1891, in which years there was a considerable increase in output. It is also a fact that the price of staple foodstuffs for cooly laborers has considerably increased of late years. Against this, however, must be set off the fact that improved means of communication have considerably lessened the time, and consequent cost of transporting these commodities. One can therefore only conclude that the scarcity of labor is really due to the fact that the profits of alluvial mining from the cooly's point of view were not so attractive as to cause, as in former years, a steady influx of labor into the Federated States. Labor poured into the country when tin stood between 32 and 37s. per pikul before 1895. Yet in 1898, with tin at $43 per pikul, with the exception of the Negri Sembilan, there was only a small increase in the labor force from outside. There was, however, a big influx to the mining districts from other parts of the Native States. The output of 1898 as compared with that of 1897 showed a decrease. In 1889-95, with tin at a lower price, there was each year an increase in the output, so that there must be some reason why labor is not attracted to the tin fields as it was formerly. This is because tin is year by year becoming increasingly harder to get on account of the gradual exhaustion of the richer deposits. Consequently, each year the miner has to work harder to produce a given quantity of tin. The annual output per cooly in 1898 was rather more than 728 lb. (5·5 pikuls), being a decrease as compared with the preceding year of 84 lb. (0·62 pikul). The average price of tin being $43 per pikul, makes the gross value $236·50 or £23 8s. To obtain the net earnings of the miner, the following deductions would be made in a mine worked on the tribute system:

Gross value, $236·50; Deductions: Government royalty, 12%, $28·38; transport and smelting, $9·62; landowner's tribute, $19·80; commission paid to mining advancer head man of cooly gang, and clerk, $8·25; total deductions,

$66·05; net earnings per annum, $170·45, or £16 17s. 2d. In 1899 the output per cooly had dropped to approximately 420 lb. (3·12 piqul).

The "truck system" of working is universal among the Chinese, so from the amount just quoted must again be deducted the mining advancer's profit on provisions supplied, and cash advanced before the tin is produced and sold. This is generally at the rate of 20%, whether for long or short periods. Thus, it is clear that the miner did not earn excessively high pay for his work, and the amount he netted was seemingly not sufficiently attractive to tempt Chinese immigration in any great quantity to the Malay Peninsula. All public works in these States are constructed entirely out of current revenue (without any financial assistance from the Imperial authorities), for which the local Government is entirely dependent on the tin industry, the prosperity or the reverse of which affects all other sources of revenue. It follows, then, that the Chinese miner is heavily taxed, directly and indirectly, whether he is at work or not. If he is earning good wages he is, to a certain extent, no doubt tempted to take more holidays, but this would only influence the tin output to a very limited extent. The Chinaman does not come to the Native States to stay, but to "make his pile" and return to his own country, so that it is more than likely he will work hard to attain this object, if he is in a paying mine.

During the last ten years these States have become more and more civilized, thus tending to raise the standard of living for the Chinese, and to increase the cost, as far as local products are concerned. The miner is thus obliged to earn more money to keep up his mode of living, and therefore, if mining on his own account (co-operative system), to work harder, or if working on wages, to raise the price of labor, when the supply is deficient. These facts are beyond dispute, and tend to show that the cooly must work harder to satisfy his wants, if tin is at a low price, than he did before, when he was a contented individual with few aspirations. If tin were now as easy to get as in former days, the result of all this would be obviously to increase the output of metal, but this is not the case.

The laws regulating labor have entirely changed during the last ten years, making the miner a perfectly free and independent agent. Before 1895, he was more or less in the hands of his employer, who was master of the situation, as the cooly was not allowed to enter into a fresh engagement without a discharge ticket from his previous one. A new law was passed abolishing *in toto* the old discharge ticket, thus reversing the order of things, and giving all the advantage to the cooly. This radical change is of course the result of British protection, and increasing civilization, which here, as everywhere else, give the laborer a freedom of action which he never enjoyed before. The principle of the new law must stand, and the employer must accept the position as irrevocable. The latter may now be less inclined to incur the expense of importing labor than formerly, but it is reasonable to expect that the present conditions should prove more attractive for free laborers.

The mutual arrangements between masters and men have also considerably altered. Formerly the general method of working the alluvial mines was by stripping the overburden on contract, and doing the other necessary work on

day's pay. This is now largely superseded by a co-operative system of leasing, whereby the miners themselves are financially interested in the quantity of tin won, and the employer, while lessening his profit, is largely able to curtail his liabilities. As may be imagined, this has tended to make the cooly more independent, for the gambling instincts of most Chinamen will lead them to prefer working where there is a spice of speculation, to a fixed wage. All these influences working together have tended to raise the price of labor in the Malay States.

The foregoing contrasts the output and circumstances of the two periods 1889-95 and 1896-98, with the result that the circumstances have all been in favor of the latter period, yet in the former there has been in each year an increase, and in the latter a considerable decrease in output. The reason of this is indirectly the labor supply, but directly the condition of the tin fields themselves. Tin mining with the metal at a low price before 1895 was attractive to the Chinese immigrant. Since then, even with an enhanced price, it has not been so attractive, because the tin is not so easy to win, and lower grade alluvials have to be worked. Thus, in the years 1896-99 the output per miner has steadily decreased. It is not possible to ascribe this entirely to the fact that the price of tin has been high, and therefore the miner has worked shorter hours, though to a small extent this may have been the case. For instance, tin land is being worked now which pays at the present high price of tin, but with tin at say $35 per pikul (the average during 1889-98), such land would not pay to work. On the other hand, the labor force employed in the mines has steadily increased during the years 1898 and 1899. For example, the number of miners in the State of Negri Sembilan alone increased from 9,000 in May, 1898, to 15,000 in June, 1899. Yet the output of tin in that State for the first half of 1899 only increased 57·5 tons as compared with the same period in the previous year. This is a clear proof that it requires considerably more laborers to keep the output of tin at its present standard. It is not so much a question, as urged by some who have given consideration to the subject, that the shallow and more easily worked tin gravels have been exhausted, and that attention must now be turned to the deeper deposits. For years, all over the Federated Malay States deep mining has been carried on conjointly with surface works, where tin is won from the grass roots down to a depth of fifteen feet. It is rather that the richest alluvials are year by year becoming worked out, and poorer ones have more and more to be exploited. To any one with a critical eye going through the tin fields of the Native States, it must be apparent what a very large amount of the proved stanniferous land has been exhausted. Acres of semi-abandoned land are to be met with, which are at present being worked by a few parties of coolies, re-washing old heaps of tailings, which are only payable owing to the high price of the metal. Another point to be noted is that of late years the Chinese methods of mining have much improved, due to the influence of coolies who have worked on the Australian and Californian diggings. Instead of stripping the overburden, as formerly, the Chinaman now, when feasible sinks small shafts and blocks out the tin bearing strata in an economical, and after his own way, methodical fashion. He

is thus enabled to work land, which it would not have paid him to strip, and to obtain by these more scientific methods a larger output, in the case of good land. Thus, were the general yield of the tin alluvials anything like so high as it was, one would naturally look for a largely increased production. Instead of this, we have a continual decrease, thereby proving that the ground now worked is not so rich.

Future Prospects.—On the subject of future prospects of tin mining in the Federated Malay States, it may be said that the figures for 1899 show fairly well what the future state of affairs is likely to be. For the first six months of 1899, there was an increased labor force, a very much higher price for tin, and yet a decrease of roughly 1,300 tons as against the same period in 1898. The output of tin per capita will continue to decrease, so that to increase the production, there must be a much more rapid influx of labor than is taking place at present. To obtain as large an output as in 1896 would require the introduction of some 50,000 more coolies, and provided the consumption of metal remained the same as it was then, tin would fall to $32 per pikul. Yet with tin at $36 per pikul in 1897, the enormous decrease as compared with 1896 made it evident that tin mining was not so attractive as formerly to the Chinese immigrant.

A good deal more than half of the world's supply of tin coming from the Federated Malay States, the output of these countries must continue to control largely the price of tin. The consumption of tin is steadily increasing, and is bound to do so year by year, as commerce spreads, so long as its price does not rise so high as to prevent its general commercial use, and no cheaper metal or alloy is found to take its place. It seems by no means impossible that one day a cheaper aluminum may prove a formidable rival to tin in some branches of manufactures. The enormous output of tin from the Malay Peninsula cheapened the metal and made its use more general. So, on the other hand, the restricted production since 1896, which failed to keep pace with the ever-increasing demand, has raised the price. Therefore, failing the discovery of equally rich and extensive tin fields elsewhere, these States, as in the past, will largely control the tin market. It is probable that the present high price of tin will attract a considerable influx of labor, but not so great as to cause a rapid increase in production. Tin at $80 per pikul makes mining an attractive proposition, but did the price drop to $35 per pikul, we should probably see a very rapidly diminishing output.

There still undoubtedly remain in the Peninsula thousands of acres, which may contain payable tin alluvial, but they have not yet been proved, so that it cannot be asserted offhand that they are stanniferous. A careful geological survey might help materially to elucidate this point. It is a significant fact that during the last seven years, no new tin fields of sufficient importance to affect the output in any way, have been discovered, although miles upon miles of roads and railway have opened up large tracts of country hitherto inaccessible. There are thousands of acres of land in the known tin fields yet to be worked, but the possibility of mining a portion of these lands at a profit will depend on the price of tin. In former times, before 1895, tin mining in the Native States seemed to be in no way dependent on the price of metal, and as this was so, undoubtedly the deposits then worked were much richer than the majority of those now left.

It is therefore safe to say that the winning of tin in the future will require more work, and more method in working. As the amount of labor available will depend on the price of tin, so will the latter now control the output. Tin lodes on the western side of the Peninsula are still to a great extent an unknown quantity, so that it is impossible to predict what effect they might have on production.

A forecast of the future is that given a continuance of the present high price of tin, and provided that no interference as regards materially increased output takes place from any other country, which would tend to wrest from the Federated Malay States their unique position as controller of the world's tin markets, these States will attract labor and perhaps to a small extent gradually increase their output. This, however, would be adversely affected by any considerable fall in price, as was the case in 1896 when tin fell to $32·07 per pikul. Broadly speaking, the tin output, like that of most other metals and substances, is based on the everlasting laws of supply and demand.

Other Parts of the Malay Peninsula.—In the Malay Peninsula are also the States of Tringanu, Kedah, Patani, Legai, Kelantan, and Kemaman, nominally under Siamese protection. These States all to a small extent produce alluvial tin, and have been worked by the Chinese and Malays for a considerable period, but it is a question whether they are likely to become an important factor in the output in the near future. It may be reasonably assumed that, were these States of the same richness in tin as the Federated Malay States, they would already have been over-run by miners, as in all parts of them are to be found Chinese traders who would always be open to any tin mining speculation.

Other Countries.—The Dutch East Indies, comprising the islands of Banka, Billiton, and Singkep, so far as one can judge from past returns, do not at present seem likely to increase their production very seriously. The same may be said more or less of New South Wales, Queensland and Tasmania. Still, big hydraulic schemes are now under way in the latter colony, which, if successful, should result in a greater output. The tin fields of Swaziland may produce more ore, when that country becomes more civilized, but their area is known to be very restricted as compared with those of the Malay Peninsula. Bolivia may prove a more serious competitor, but the country labors under the heavy disadvantages of difficult transportation incidental to a highly mountainous country, the natural indolence of its people, and the very unstable form of government peculiar to Spanish-American republics. Improved machinery, and the stimulus of better prices, are doing something for Cornwall, the mother of the tin mining industry, but still we see barely 20 mines now at work in the west of England, some, it is true, on a larger scale than formerly. At the present time there are no indications that the tin output of the rest of the continent of Europe will not remain as insignificant as in times past. Germany and Austria-Hungary only continue to produce tin in very small quantities. Lode mining goes on in places in Spain and Portugal, but so far has met with no great success. Encouraged no doubt by present high prices, hydraulic mining schemes are being projected in Spain, notably in Galicia in the northwest, but no data as to results are as yet at hand.

TUNGSTEN.

THE production of tungsten ore in 1900 was 220 tons of high-grade quality ranging from 60 to 70% tungstic acid. In addition to this output there was a considerable amount of lower-grade ore produced from South Dakota and Connecticut. The prices of tungsten ore in 1900 varied during the year; about one-half of the mined product was sold at an average of $160 per ton. The production during 1900 of metallic tungsten, ferrotungsten, tungstic acid and sodium tungstate amounted collectively to 152,000 lb. Owing to the keen competition that exists among the dealers, statistics of individual production were withheld. The price of tungsten metal varied from 82c. to $1 per lb., while ferrotungsten was quoted at 30@35c. per pound.

Up to very recent years the United States imported all the tungsten it used, the sources of supply being England, Austria-Hungary, Saxony, Germany and Australia. The constant growing demand from America for tungsten to be used in the steel industry led to prospecting in the United States for the mineral, with the result that it was discovered to exist in many of the States and Territories in quantities commercially valuable. As, moreover, it is a by-product in gold and silver mining, the production of the mineral on a large scale in America would seem to be only a question of time.

Arizona.—In the Arivaca district, in Pima County, the reported average value of the ore taken out was, tungsten 50%, $20 gold and $20 silver; 8,000 lb. of ore at the end of the year were awaiting the completion of the concentrating plant in process of erection at the mines. In the Dragoon Mountains, in Cochise County, 13 miles from Benson, huebnerite was discovered, but the deposits have not yet been opened.

Colorado.—At a number of the gold and silver mines of San Juan County, huebnerite has been found in gold quartz veins in sufficient quantity to make it a valuable by-product. Scheelite has sometimes been found associated with it. At Red Mountain, Ouray County, and in many of the Leadville mines, wolframite and huebnerite have been found. During the year 1900 the production was as follows: San Juan County, 5,000 lb., 71% tungstic acid, and 6,000 lb., 68%; Boulder County, 80,000 lb., 65% tungstic acid; a total of 91,000 lb. This ore was marketed in Eastern cities, and was sold, at place of delivery, at prices

ranging from $2 to $3·50 per unit tungstic acid. The discovery of tungsten in the granite-gneiss-schist-complex of Boulder and Gilpin counties, resulted in considerable systematic prospecting, with the result of establishing the existence of tungsten in commercial quantities in both the northern and southern sections of the State. It occurs in small streaks and pockets, or is disseminated through fissure veins with other minerals.

Connecticut.—Near Long Hill, in Trumbull township, about 9 miles north of Bridgeport, the American Tungsten Milling & Mining Co. began the mining of scheelite on a large scale. The occurrence of scheelite has been known for many years, and mining was once carried on there for bismuth, lead, silver and copper. The scheelite occurs in a vein of quartz lying between an amphibole-gneiss of a dark black color and a bed of crystalline limestone. The percentage of scheelite in the veins is about 5%. A very complete plant for separating and concentrating the ore has been erected by the company. In the treatment of the tungsten minerals the Hooper pneumatic system is used, with six pneumatic concentrators. The ore having been thoroughly crushed at the mill, is treated by the rolls, screened and thence goes to the hoppers from which it is fed to the concentrators. The process gives nearly a pure concentrate with the exception of the pyrite, the most of which goes with the scheelite. Analyses of the concentrates of scheelite gave values of tungstic oxide (WO_3) varying from 67 to 70%, and of wolframite from 55 to 60%.

Nevada.—Early in 1900 a huebnerite-bearing vein was discovered about 12 miles south of Osceola, near the base of Wheeler's Peak, and in April, 1900, a plant with a crusher and jig was installed. The vein in which the huebnerite occurs is a coarse porphyritic granite of the usual quartz-mica-hornblende variety. The main vein is normally 3 ft. in width. The ore occurs in solid masses, frequently attaining a thickness of 6 to 12 in. In one locality in the vein the ore was found in large blocks averaging 75% of tungstic acid.

South Dakota.—Several tons of wolframite ore were mined and shipped from Sunday Gulch, near Oreville, Pennington County and from the Harrison mine at Lead.

In *California, Idaho, Montana, New Mexico, North Carolina, Oregon* and *Washington* deposits of tungsten minerals have been found.

Nova Scotia.—The wolframite deposit at northeast Margaree, Cape Breton, has been operated during 1900, and one block of quartz taken out in tunnelling contained half a ton of ore, which gave the following analysis: WO_3, 66·32%; SiO_2, 6·25%; Mn, 12·02%; Fe, 12%. Huebnerite has been produced in some quantity at Emerald, Inverness County.

Australia.—During 1899 the production of scheelite in New South Wales amounted to 94 tons, valued at £3,710, which was derived mainly from the mines at Hillgrove, and in 1900 New Zealand contributed about 100 tons of scheelite from Macrae's, Otago, the product being shipped to Europe. Two hundred and fifty-eight long tons of wolframite ore were produced in Queenstown, N. S. W., in 1899, and during the first three months of 1900, 27 tons of wolframite ore were produced at the Storey's Creek mines, New Zealand.

ZINC AND CADMIUM.

THE production of metallic zinc or spelter in the United States during 1900 amounted to 123,231 short tons, a considerable decrease from the production in 1899, which was 129,675 short tons, the largest amount yet recorded for a year's output. The production of spelter by districts is shown in the subjoined table:

PRODUCTION OF ZINC IN THE UNITED STATES.

States.	1895.	1896.	1897.	1898.	1899.	1900.
Illinois and Indiana	33,748	31,656	38,680	46,693	49,290	37,558
Kansas	25,916	36,566	33,395	38,543	55,872	57,276
Missouri	10,726		18,412	21,063	15,710	20,138
South and East	11,468	9,415	9,900	7,805	8,803	8,259
Total tons of 2,000 lb.	81,858	77,637	100,387	114,104	129,675	123,231
Total tons of 2,240 lb.	72,088	69,319	89,623	101,879	115,781	110,028
Total metric tons	74,245	70,432	91,071	103,514	117,644	111,794

There was a great falling off in the production of the Illinois-Indiana district, due in part to the removal of the smelting plants to the Iola district in Kansas, where the cost of production is considerably less, natural gas being used as fuel. The production of Missouri and Kansas showed a marked increase for the reasons set forth in the section on the "Progress in the Metallurgy of Zinc in the United States, during 1900," given later in this chapter. The mines in the Leadville district, Colorado, have contributed a considerable portion of zinkiferous tailings and ores, material which has heretofore been regarded as waste. About 14,000 tons were shipped in 1900, of which the greater part was consigned to Europe, chiefly to the Vieille Montagne works, via Galveston and New Orleans. In the Eastern and Southern districts there was a decrease of 544 tons in 1900, the production for that year and for 1899 being respectively 8,259 tons and 8,803 tons. The ore supply from these works was derived from the mines in New Jersey and in southwestern Virginia.

As in previous years, the principal producers in the Illinois district were the Matthiessen & Hegeler Zinc Co. and the Illinois Zinc Co. In addition to these were three smaller companies. Of the eight companies operating in Kansas, the Lanyon Zinc Co. was the chief producer, while in Missouri, The Edgar Zinc Co. contributed the greatest output of the works located there. The New Jersey Zinc

Co. remains the sole producer in the East, and the Bertha Mineral Co. the main producer in the South. The Joplin district furnished ores for a large part of the Western smelters, although during the past year zinkiferous tailings and zinc ore have been treated in a few of the smelters in Illinois.

The United States Board of General Appraisers gave a decision, August 6, 1900, that zinc dust (zinc gray) should be admitted into the United States as a crude material free of duty under the existing tariff law on the ground that an article may be crude for the purpose of classification under the tariff laws, by reason of the use to which it is to be applied, where it is crude in the sense that it is unrefined, although it may be the result of some process of manufacture.

A large amount of zinc dust is now utilized in the precipitation of gold from cyanide solutions. From 6 to 9 oz. of dust is used per ton of pregnant solution, one ton of which represents 2·5 tons of ore. The cost of precipitating precious metals from cyanide solutions is stated to be but little more than 2c. per ton of ore treated at De Lamar, Nev., and a little less than 3c. at the Consolidated Mercur, Utah. At the end of 1900 it is stated that the cyanide solutions from at least 3,000 tons of ore were being treated daily by zinc dust precipitation. All of the ore so treated is comparatively low grade.

The production of zinc oxide in the United States in 1900 was 47,151 short tons, against 39,663 short tons in 1899, an increase of 19%. The average value of this material at the works during 1900 was $80 per short ton, against $84 in the previous year. The greater part of this output was made by the New Jersey Zinc Co., operating at Jersey City and Newark, N. J., Bethlehem and Palmerton, Pa., and Mineral Point, Wis. Page & Krause at St. Louis, Mo., produces annually between 400 and 500 tons and the American Zinc and Lead Co., of Cañon City, Colo., manufactures of pigment called "zinc-lead" which is a mixture of oxidized compounds of zinc and lead. A new company has been formed at West Plains, Mo., called the G. G. Zinc Oxide Co., its plant being completed toward the end of the year.

PRODUCTION OF ZINC OXIDE IN THE UNITED STATES.

Year.	Quantity.		Value.		Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Tons.		Short Tons.	Metric Tons.	Totals.	Per Short Ton.
1897.....	26,262	23,825	$1,686,020	$64·20	1899.....	39,663	35,982	$3,331,692	$84·00
1898.....	32,747	29,708	2,226,796	68·00	1900.....	47,151	42,775	3,772,080	80·00

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES. (IN POUNDS.)

Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.	Oxide.	
					Dry.	In Oil.
1896.....	856,044	$25,904	$15,728	$41,632	4,572,781	311,023
1897.....	2,557,341	95,883	19,431	115,314	5,564,753	502,357
1898.....	2,742,357	109,624	13,448	123,072	3,342,235	27,050
1899.....	2,985,463	151,956	14,800	166,756	3,012,709	41,699
1900.....	2,013,196	97,762	36,836	134,598	2,618,808	38,706

EXPORTS OF ZINC AND ZINC OXIDE FROM THE UNITED STATES. (IN POUNDS.)

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
1896.....	4,648,000	$47,408	20,300,169	$1,013,620	$51,001	$1,112,029
1897.....	*a* 22,220,907	315,490	28,490,662	1,356,538	71,021	1,743,049
1898.....	*b* 31,413,859	552,064	20,998,413	1,033,959	138,165	1,724,188
1899.....	*c* 67,126,506	1,092,542	13,509,316	742,521	143,232	1,978,295
1900.....	*d* 95,514,893	1,630,043	44,820,915	2,217,963	99,288	3,947,024

(*a*) Includes zinc oxide, 3,718,507 lb. ($104,140). (*b*) Zinc oxide, 7,849,059 lb. ($252,194). (*c*) Zinc oxide, 10,685,226 lb. ($366,598). (*d*) Zinc oxide, 11,391,693 lb. ($496,380).

The use of zinc chloride for preserving railroad ties was developed to a considerable extent during 1900. It is estimated that the nine concerns now engaged in this industry consume 2,975,000 lb. annually.

The American Smelting & Refining Co. at Argentine, Kan., produced in 1900 1,054,676 lb. of zinc sulphate as a by-product in smelting lead ore. This zinc salt was also manufactured by several chemical companies in the United States. The greater part of the output is consumed in the manufacture of glue and special paints.

Arkansas.—In the southwestern part of the State, the old Petty zinc-lead mine near Gilham, Sevier County, is being developed by the North American Ore & Metal Co. The main shaft has been sunk to a depth of 125 ft. and the second shaft to 115 ft. The concentrated ore has been shipped to Joplin with satisfactory results, the average assay of one shipment of 57,000 lb. showing Zn 55·16%, Fe 3·91%. As the basis of ore sales at Joplin is 60% Zn and 1% Fe, a deduction of $1 per ton is made for each per cent. of zinc below 60% and for each per cent. of iron above 1%. To enrich the present product a reverberatory furnace and a magnetic separator will be erected. The output was stated to be 50 tons per day early in 1901, an amount that will be increased after the addition of the roasting furnace and magnetic separator.

Colorado.—The main feature of the zinc mining industry during 1900 was the large increase in the shipment of zinkiferous ores and concentrates. A few of the Leadville mines have always produced material of this character that involved so high a treatment charge at the smelters as to require dressing in order to remove the objectionable zinky portion. In this way large quantities of tailings have accumulated which, with the crude zinc ores formerly regarded as waste, have been recently shipped to zinc smelters, the greater portion being sent to Belgium via Galveston and New Orleans, and the remainder to Iola, Kan., Mineral Point, Wis., and to Indiana. At least 14,000 tons of the material were shipped abroad in 1900, against 8,000 in 1899. The Wilfley table has been successfully used for the separation of the lead-iron-silver product from the zinkiferous portion, the former being an excellent fluxing material for the lead smelters. The purchasers of tailings and waste ores do not pay for the small amount of gold and silver contained. A shipment of zinc tailings from the A. Y. & Minnie mine was made to the works of the Nickel Copper Co. of Ontario, Ltd., at Hamilton, for experimental purposes.

Iowa.—(S. W. Beyer.)—The mining operations in and about Dubuque were carried on less vigorously during 1900 than for the two years preceding. This

was in part due to falling prices and in part due to the fact that two of the leading companies being engaged in litigation during the greater portion of the year, active operations were at a standstill in their respective properties. About 2,000 tons of crude zinc ore was produced, selling at from $6·50 to $12 per ton, according to quality, the average price being about $8, giving a total of $16,000 for the output of the district. A portion of the ore was roasted by the Dubuque Ore Concentrating Co., and all of the ore was sold to the Mineral Point Zinc Co., of Mineral Point, Wis. The ore, as in 1899, consisted principally of zinc carbonate, with disseminated particles of zinc sulphide. Prospecting was carried on quite extensively during the year, but chiefly for lead. The outlook for 1901 is not specially encouraging, although the amount produced will probably exceed the product of 1900.

New Jersey.—(Through the courtesy of A. Heckscher.)—During the year 1900, the operations of The New Jersey Zinc Co. in Sussex County, where its principal mines are located, have been practically confined to the Mine Hill deposit, near Franklin Furnace, only 1,859 tons of ore having been shipped from the Stirling Hill deposit, which is now idle. It has been found that the ores from Stirling Hill, while abundant, are leaner than those at Mine Hill, and that greater economy can be secured for the present by discontinuing work on Stirling Hill.

The second and larger concentrating plant, near Franklin Furnace, utilizing the Edison system of crushing, ore-drying and sizing, and the Wetherill system of ore separation, has been finished and is now in operation. The Edison system, devised for fine grinding, is not in all respects well adapted for the crushing of franklinite ore, where the aim should be more particularly to avoid an excess of fines; these in the Wetherill system of separation are more difficult of treatment. Substituting an adaptation of Cornish rolls for the three high rolls of the Edison system, that portion of the mill which grinds, dries and sizes is now complete and the Wetherill magnetic machines recently installed have given excellent results on the complex minerals of iron, zinc and manganese, constituting franklinite. The capacity of the older mill has been brought up to 500 tons in 24 hours, and has at times been over-taxed by the requirements of the company's manufacturing plants. In the new mill it is expected that 1,000 tons in 24 hours can be readily treated. The tonnages of ore in the crude state, delivered to both mills, during the year, and the tonnages forwarded to the works of the company and for export have been as follows: Crude ore to mills, 198,262 long tons; crushed crude ore shipped, 37,622 tons, and crushed concentrates shipped, 148,917 tons; total, 186,539 tons. Deducting crude ore shipped it will be seen that 160,640 tons produced 148,917 tons of concentrates or nearly 93%, a remarkable showing in view of the fact that the bulk of the product resulted from development work in the deep levels of the mine.

At South Mine Hill, where the deposit spoons up and outcrops at the surface, the usual system of stripping and of open-cast work has been continued. In the deep, or Parker shaft, the work of exploration both north and south on the deposit has been actively and continuously urged forward.

Progress has also been made at Palmerton, Pa., near Mauch Chunk, on the

line of the Central Railroad of New Jersey, in the unification and centralization of the company's manufacturing operations. The new zinc oxide plant has been worked economically and successfully. Its capacity is now being doubled, so that the production before the end of 1901 will be at the rate of 100,000 lb. daily. The new spelter furnaces have been exhaustively tested and it is proposed to increase their number. Plans are in hand and well advanced for the present erection of a sheet zinc rolling mill, and the manufacture of lithophone will be taken up on a comprehensive scale before the end of the year. It is also proposed to erect two large modern spiegeleisen furnaces for the utilization of the iron and manganese residues from franklinite after the extraction of the bulk of the zinc in the Wetherill process of zinc oxide manufacture. The Palmerton plant will in time manufacture all the products of zinc and the by-products of iron and manganese from the ores of the company's mines.

At Mineral Point, Wis., the Mineral Point Zinc Co., affiliated with The New Jersey Zinc Co. and under its control, has continued the manufacture of zinc oxide and has operated during a portion of the year its new plant for the manufacture of sulphuric anhydride under the Grillo-Schroeder process. The latter plant is now idle for needed alterations and repairs and will shortly resume the manufacture of high-grade acid.

Missouri and Kansas.—While the production of zinc in other districts throughout the United States showed in 1900 a serious falling off from the extraordinary yield of the year before, the output in the Missouri-Kansas zinc mining district exceeded by 7·6% the output of 1899. The influx of a flood of new capital during 1899 led to many changes in methods and business management which, in the long run, have proved of benefit to the mining interests involved. The companies have in general continued the sub-leasing system under which the mining industry has grown, and to which is largely attributable the fine character of the mining population in this district. Among the companies that derive large profits from sub-leasing their ground are the Missouri Lead & Zinc Co., the American Zinc, Lead & Smelting Co., the Boston Little-Circle Zinc Co., the Old Colony Zinc & Smelting Co., and the United Zinc Co. There were many object lessons during the year on the folly of replacing tried machinery successfully used in this district for concentrating ore with experimental machinery, satisfactory enough in other mining camps for other minerals, but inapplicable to conditions here. The most costly experiment of this kind made during the year was that of the Missouri Blanket Vein Zinc Co. which, after spending $40,000 in building a mill after a new model on its property at Center Valley, between Webb City and Oronogo, tore the structure down and rebuilt it on the plan of the company's earlier plant at Prosperity. As was to be expected in the general prosperity in zinc mining during 1899 and the early part of 1900, many unscrupulous promoters flocked to the district and the great returns from legitimate investments were used to further swindling enterprises; these resulted in heavy losses to gullible investors, and the reputation of reliable promoters and reliable zinc companies suffered in consequence. These frauds, coupled with the wasteful and extravagant management of many really good properties, discredited zinc investments for a few months and checked mining transfers during the summer

and early fall. But from all this experience there has arisen a better knowledge of conditions and a better understanding of the best methods of operation. The recorded investments in the entire district during 1900 amount to a little over $5,000,000, as against $12,000,000 last year. These were mostly made by close corporations or private individuals.

In general the mining industry was very active and the close of the year 1900 saw more new mills in course of erection than at any one time in 1899. On the 80-acre tract at Joplin, the United Zinc Co.'s five new mills were completed in December, six mills were going up on the ground of the Missouri Zinc Fields Co. at Carterville and three were nearing completion on the land of the Calumet Zinc & Lead Co. at Neck City. There was no appreciable cut in wages during the year, in spite of the lower prices that prevailed for zinc ore. Miners were scaled down relatively little, unskilled labor was paid $1·75 to $2 per day, while good ground men and ground bosses received from $2·25 to $3·25 per day. There were no labor disturbances of any kind during the year except a few trifling disagreements.

The successful use of gas as a fuel at the smelters in the Kansas natural gas belt, and its superiority in the securing of economy and speed, have resulted in the abandonment of the coal smelters at Pittsburg, Nevada and other locations in Missouri and the building of great gas smelters at Iola, La Harpe, Gas City, Coffeyville, Cherryvale and other Kansas points and in the conversion of the coal furnaces of the Matthiessen & Hegeler Zinc Co. at La Salle, Ill., into coal gas furnaces. The decrease in demand for ore while the making of these changes tied up the smelters, has had much to do with the unsettled and lower ore prices that prevailed, but there were no sudden and violent changes in the market in 1900, and the prices for both lead and zinc ores were fairly satisfactory to those possessing good mines. The Missouri & Kansas Zinc Miners' Association was reorganized and was incorporated during December with a cash capital sufficiently large to enable it either to hold or to export large quantities of zinc ore, and its control is now in the hands of large producers of the ore.

The output of the district of which Joplin is the center, for the last two years, in pounds, was as follows:

Year.	Zinc Ore. Lb.	Lead Ore. Lb.
1899.....	511,657,470	48,212,720
1900.....	484,660,410	59,013,390
Decrease.....	26,997,060	
Increase.		10,800,670

The year opened with the best grades of zinc ore selling at $36·50 per ton; the price fell to $25 for the week ending June 30, the lowest point during the year. The first week in December a large sale was made at Stotts City for $30·75, and the closing price was $27·50. The average top price for 60% ore or better for the year was $30·28, but the average selling price of all grades was much lower. The fight between the gas and the coal smelters during 1899 forced zinc prices up to the highest point yet known, but finally ended with a

compromise at the close of the year. The bitterness of the contest can be judged by a comparison of the prices paid for zinc ore, which were as follows:

Month.	1899.	1900.	Month.	1899.	1900.
January.....	$32·25	$35·125	July.....	$44·20	$27·50
February.....	43·375	34·50	August.....	45·00	28·375
March.....	43·40	32·60	September.....	43·75	27·70
April.....	51·50	32·875	October.....	43·50	28·50
May.....	50·50	30·625	November.....	35·00	28·875
June.....	45·50	27·80	December.....	36·00	28·95

The combined value of the output of zinc and lead ore for 1900 was $7,977,304, against $10,863,628 for 1899. The zinc output decreased 26,997,060 lb., but the lead sales increased 10,800,670 lb. The decrease in zinc production was due to the closing down of properties which were bought when zinc ore was selling at high figures.

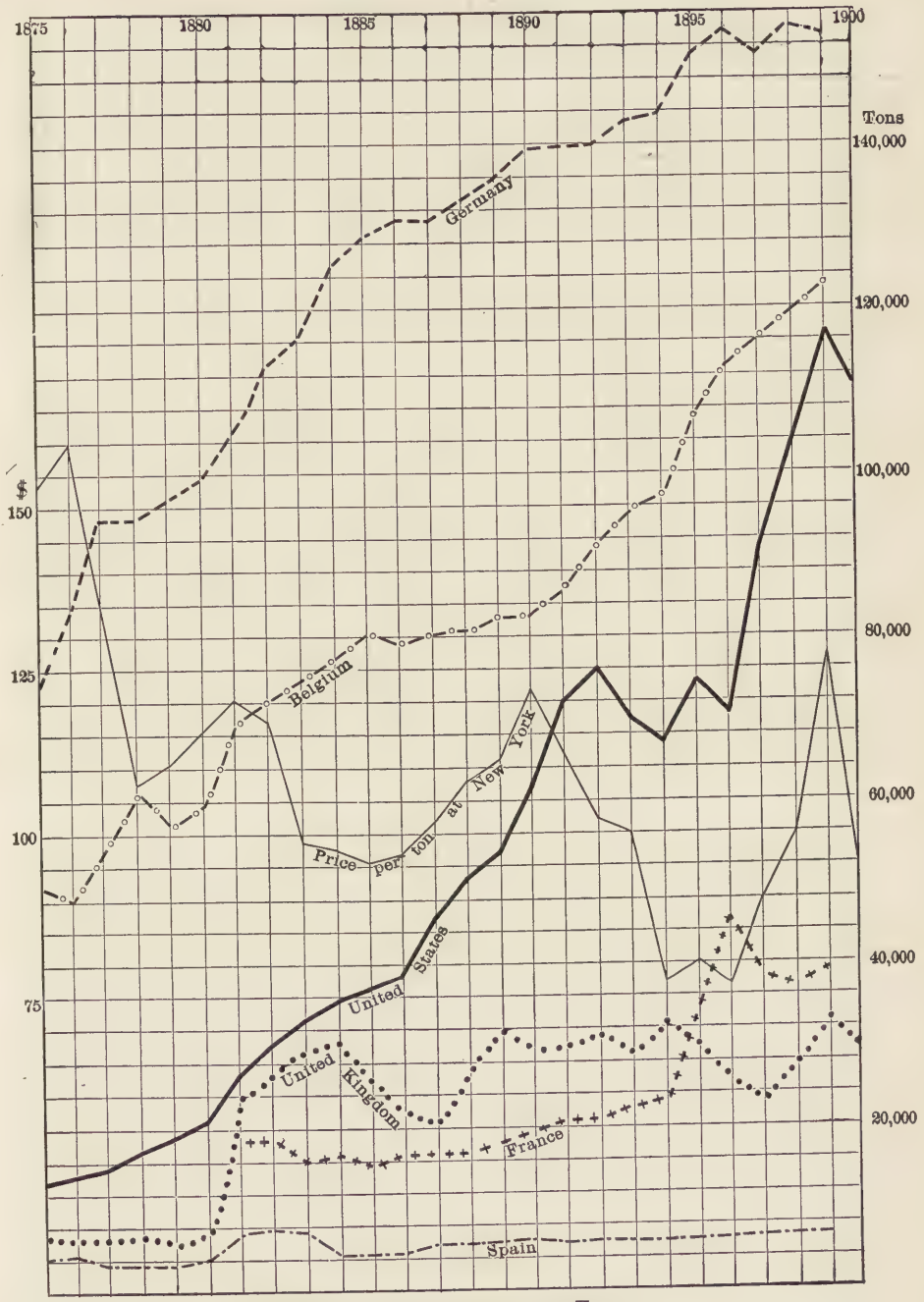
The general method of mining at Joplin and the present method of ore purchasing have been given in the "Review of Progress in the Metallurgy of Zinc in 1900" which appears later in this chapter.

Tennessee.—(R. A. Shiflett.)—The zinc mines of Tennessee were operated only to a small extent during 1900, the mines at New Prospect and Mossy Creek being tied up since August by litigation. The Seven Day Zinc Mining Co. is developing a mine near McMillin Station in Knox County. The ore is associated with dolomite and assays from 8 to 15% of mineral containing 55·5% Zn; lead, copper and iron are absent. A large deposit of pure carbonate ore was opened up at Mascot, on the line of the Southern Railway, and material to the value of $11,600 was shipped to smelters in Indiana. Plans for a zinc smeltery at Mascot are in contemplation. The production of zinc blende in 1900 was 3,968 short tons, against 3,799 short tons in the previous year.

Virginia.—There is but little of interest reported during 1900 in the zinc mining industry in southern Virginia. The usual amount of prospecting work has been carried on, but no discoveries of any commercial importance have been made; this work has been chiefly in magnesian limestone carrying disseminated blende, and the lack of success that has attended it makes it quite certain that the ores of this class are of no commercial importance in this section of the country. At the Bertha mines, in Wythe County, the work of stripping the calamine deposits has continued on a large scale. The covering of iron bearing clay is washed to produce a good grade of iron ore which is used in the blast furnaces of the locality. The Bertha Mineral Co. has completed a large mill for the separation of the mixed ores, at its Clark mines, Pulaski County, Va., and pending the completion of the mill, zinc ore of the free grade only is being shipped. The Wythe Lead and Zinc Mines Co. is carrying on its usual mining operations at Austinville. A mechanical roaster has been installed during the year which has replaced the old hand-operated, reverberatory roaster heretofore used.

Wisconsin.—(E. R. Buckley.)—The lead and zinc region comprises the greater part of three counties in the southwestern part of the State, having a total area of about 2,500 square miles, and for over 65 years mining has been engaged in

in this part of the State. Prior to 1860 the commercial value of the zinc which occurs associated with the lead of this region was unknown. The zinc ores—sphalerite and smithsonite—known to the miners as black jack and dry bone, were during this early period, thrown on the dumps and spread over the roads from which later when their value had become known, they were gathered and shipped to the smelters. The lead ore occurs in the form of galena, while the zinc ore is found as sphalerite and smithsonite with occasional small deposits of calamine. The minerals occur very largely in what is known as galena limestone. The beds which comprise this formation are not absolutely horizontal, but are rather undulatory, giving the impression of having been slightly folded. The rocks are traversed by fissures or jointing planes, which strike in several directions. The ore is found largely between the beds or in the vertical and inclined fissures, and it occurs in what is known as pitches and flats. The flats usually follow bedding planes and constitute sheets of ore, parallel to the bedding. The pitches are sheets of ore which are inclined and sometimes normal to the bedding. These sheets vary in thickness from a fraction of an inch to 10 inches. The sheets themselves vary in thickness in different parts. Mining in this region has been conducted in a very simple and crude fashion for many years. Nine-tenths of the mines are worked by horse and man power. The drills are largely operated by hand and the hoisting is frequently done by means of a hand windlass. In spite of this the country has supported a thrifty population and a considerable quantity of lead and zinc has been mined and sold throughout the region. Up to within a few years there was no thought of mining beneath what is known as the water level, it being generally supposed that mining below this would prove unprofitable. During the last 30 or 40 years, the water level in this section of the country has fallen 10 or 15 ft., and has permitted the lowering of shafts in mines which had formerly reached the level of the underground water. It is between the former and the present water levels that the bulk of the sphalerite or zinc sulphide has been mined. In this region the galena and smithsonite occur mainly above the former water levels while the sphalerite or zinc sulphide is found deeper within the mines. The smithsonite is an alteration product of the sphalerite and it is not an unfrequent occurrence to find the two associated in such a manner as to prove quite conclusively that this has been its origin. At the lower levels zinc also occurs disseminated throughout the rock, in cavities, caves, and pockets. At these lower levels calcite and pyrite are relatively abundant and are often so intimately associated with the ore as to require crushing and careful sorting. During the last two years a new impetus has been given to mining in this region and development has progressed more rapidly than before. Of 12,500 tons of zinc ores raised and sold from a single mine near Benton in the past nine year, 77% was in coarse pieces ready for the market. Improved methods of mining and handling the ores will place many of the now doubtful mines on a paying basis. Much of the rock which is "shot" through and through with zinc ore has been left in the mines untouched owing to insufficient machinery for handling it. The shipments from the more important centers of the region amounted to 15,000 tons for the year 1900.



THE WORLD'S PRODUCTION OF ZINC
IN METRIC TONS

The above diagram represents the production by smelters and includes zinc made from both foreign and domestic ores. In Belgium a large part of the output is derived from imported ores, and this is true also of the United Kingdom and France. The United States, Germany and Spain are exporters of ore.

THE PRODUCTION OF ZINC AND ZINC ORES IN THE WORLD.

PRODUCTION OF ZINC IN THE WORLD. (IN METRIC TONS.)

Year.	Austria. (a)	Belgium. (b)	France. (b)	Germany (b)	Italy. (b)	Russia. (d)	Spain. (b)	United Kingdom. (c)		United States. (e)	Totals.
								Native Ores.	Foreign Ores.		
1896	6,888	113,361	45,585	153,082	*Nil.*	6,257	6,133	7,224	18,054	70,432	417,016
1897	6,236	116,067	38,067	150,739	250	5,868	6,244	7,162	16,643	91,070	438,346
1898	7,302	119,067	37,155	154,867	250	5,664	6,031	7,162	21,225	103,514	462,237
1899	7,192	123,000	39,274	153,155	251	6,325	6,184	8,837	23,385	117,644	485,246
1900	6,836	(f)	*h* 38,000	(f)	250	5,969	6,200	30,307		111,794	

(a) The statistics for Austria are taken from the official reports of the Mines Department, except for 1900, for which the figure reported by Henry R. Merton & Co. has been used.
(b) Official statistics, except for 1900.
(c) The statistics for the United Kingdom are arrived at by deducting the zinc produced from domestic ores, as reported in the official Blue Books, from the total output of the smelting works as stated in the reports of Messrs. Henry R. Merton & Co.
(d) From official reports, except the figures for 1899 and 1900, which are reported by Henry R. Merton & Co.
(e) Statistics compiled from direct returns by the producers to THE MINERAL INDUSTRY.
(f) According to Henry R. Merton & Co., Belgium, Holland and the Rhine district of Germany in 1900 produced 189,301 metric tons of spelter, against 192,994 in 1899; and Upper Silesia produced 102,316 (100,167).

PRODUCTION OF ZINC ORE IN EUROPE. (IN METRIC TONS.)

Year.	Algeria	Austria	Belgium.	France.	Germany.	Greece. (b)	Italy.	Norway. (a)	Russia.	Spain.	Sweden	United Kingdom
1895.....	14,300	25,862	12,230	72,989	706,423	24,031	121,197	(c)	57,213	54,109	31,349	17,758
1896.....	17,587	26,887	11,639	81,346	729,942	22,700	118,171	450	59,680	64,828	44,041	19,629
1897.....	32,269	27,463	10,954	83,044	663,850	30,906	122,214	908	54,524	73,848	56,636	19,587
1898.....	29,800	27,395	11,475	85,550	641,706	32,045	132,099	320	(d)	99,836	61,627	23,929
1899.....	42,970	36,100		84,813	664,536	22,907	150,629	(d)	(d)	119,710	65,159	23,505

(a) Zinc-lead ore. (b) Including blende and calcined calamine. (c) Not reported in the government statistics. (d) Statistics not yet published.

THE SPELTER MARKETS IN 1900.

New York.—In contrast with 1899, the year 1900 does not show wide fluctuations in the price of spelter. In the former year both foreign and domestic demand was very heavy, and at frequent periods supplies proved inadequate, resulting in an advance of price to 6·875c. per pound; in the latter year production was always sufficient to meet both the home and the European demand.

American consumption appears to have slightly decreased. For brass purposes the same quantities were used as heretofore, but the galvanizers did not take the usual quantities. The depression in the iron trade affected the demand for galvanizing material. The close of the year found the iron market in better shape, with prospects for a larger demand for iron for galvanizing purposes in the present year. The exports for 1900 were 20,669 tons, as against 6,482 tons for 1899. The foreign market was not able to bear the pressure of these quantities, their home production being quite sufficient for the demand. In fact, at times considerable stock accumulated in the hands of the European smelters. Under these conditions the European market was frequently below the parity at which exports were possible. This, in turn, re-acted upon our market in so far as the quantities available for delivery in this country became larger.

The production of spelter in the United States has decreased for the reason that the price ruling for zinc ore has been lower, which has made the mining

of this commodity less attractive. It has, furthermore, made it impossible for companies floated on the basis of last year's values and prices to pay dividends, with the result that during the past year operations were in many cases suspended.

The year opened with spelter selling at 4·25c. St. Louis. The market had a downward tendency until the end of January, when a good domestic demand sprang up, and the foreign market also began to advance. It became apparent that the foreign market would absorb considerable quantities, and buying became quite aggressive.

At the end of January, and during February, a large export business was done and prices moved up to 4·70c. St. Louis. The demand being satisfied, a dull and dragging market followed, which, during March, carried prices down to 4·35c. In April a turn came, home buyers, who had quite depleted their stocks, now entered the market both for early and distant deliveries; the European market also took large quantities, and prices advanced again to 4·60c. St. Louis. May was another dull month, during which the market moved sluggishly downward to 4·375c. St. Louis.

During June the metal sold down to 4c. St. Louis. At this low price buyers took hold quite largely, and the production of zinc ore became heavily curtailed, as the miners would not go on at the figures then ruling. At the end of the month a sharp advance took place to 4·15c. St. Louis. The market continued active during July, when 4·25c. was reached. During August the market was very dull, and in September it declined to 3·95c. St. Louis.

In October demand improved somewhat and the market advanced to 4·05c. St. Louis. But requirements were soon filled and the market became very dull, when a heavy domestic business, together with a decrease in production, owing to the shutdown of the coal smelters, brought prices to 4·15c. St. Louis. During December a fair business was done, though at a lower figure, St. Louis selling at 4c.

AVERAGE MONTHLY PRICES OF SPELTER IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1896	3·75	4·03	4·20	4·09	3·98	4·10	3·97	3·76	3·60	3·72	3·99	4·14	3·94
1897	3·91	4·02	4·12	4·13	4·21	4·21	4·32	4·26	4·18	4·17	4·03	3·89	4·12
1898	3·96	4·04	4·25	4·26	4·27	4·77	4·66	4·58	4·67	4·98	5·29	5·10	4·57
1899	5·34	6·28	6·31	6·67	6·88	5·98	5·82	5·65	5·50	5·32	4·64	4·66	5·75
1900	4·65	4·64	4·60	4·71	4·53	4·29	4·28	4·17	4·11	4·15	4·29	4·25	4·39

London.—January commenced with ordinaries quoted at £20 12s. 6d., but in face of the free offerings from America there was a drop to £20 5s. On the cessation of these offers, however, there was a sharp advance, owing to the demand for galvanized iron and sheet zinc, to about £20 10s.

February found producers on the Continent holding for full values, but America was selling rather freely, and as the quantities available seemed to be in excess of what was expected, consumers became shy, and owing to the want of demand prices suffered and declined from £22 10s., which had been touched earlier in the month, to £21 12s. 6d. Early in March there was again a resump-

tion of buying both here and on the Continent, and an improvement was noted to £22, specials being worth about 10s. premium; but on the renewal of free offers from America there was a quick retrograde movement to £21 2s. 6d.

In April the published statistics showing exports of galvanized iron at 26,441 tons for the month helped to make the tone firm, and owing to the withdrawal of American offers prices quickly recovered to £22 10s. for ordinaries. After a good business had been done at this level there was a slight setback of about 5s. per ton. May opened with a somewhat dull tone, caused principally by the weakness of the other metal markets, this fact causing the realizations of some speculative parcels, and the market was forced down to £21, improving again, however, owing to the strength of the sheet zinc trade, to £21 15s.

June commenced with a dull market at £21 for ordinaries, and £21 10s. for specials; America was offering freely, and these offers continued throughout the month, causing prices to recede to £19 5s., ordinaries, £19 10s., specials. A good demand from galvanizers and consumers of sheet zinc being found early in July, there was a quick recovery to £20 5s., but this level could not be maintained, in consequence of the unsatisfactory state of the galvanized iron market, and prices quickly dropped to £19, steadying, however, to the extent of about 10s. a ton before the end of the month. Throughout August the market was fairly steady, hovering between £19 7s. 6d. and £19 12s. 6d. for ordinaries.

September again witnessed free offerings of American metal from second-hand holders, causing a decline to £18 15s., but at this period good orders for galvanized iron were placed by the English Government and by Indian merchants, which drew other consumers in, and values improved to £19 7s. 6d. October commenced with ordinaries quoted at £18 15s., but consumers on the Continent were paying high prices there, and this caused a quick rally in London to £19 10s., followed, however, shortly after, by a break, sales again being made as low as £18 15s. November commenced at this figure, but when it was found that the position in America was sounder, and that the Americans were not offering material for export, the market again took an upward turn and advanced to £19 7s. 6d.

December found an extraordinary apathy on the part of buyers, and the market was quite neglected for days at a time; prices consequently suffered, and they declined to £18 10s. A small improvement in the demand brought prices up to £18 12s. 6d. for good ordinaries and £18 17s. 6d. for specials at the end of the year.

Breslau.—The market for 1900 showed the effects of the high prices that prevailed in the preceding year both in the limitation of the domestic demand and in the larger exports of American metal to England. Consumption in South Africa and China was curtailed by the unsettled condition of business in these quarters. While the demand for zinc fell of to a marked extent, there was no large depreciation of values owing to the moderate production. For the smelters, however, the year was not a prosperous one, as the market offered no compensating factor against the high costs of fuel. The average prices of spelter reported by the Royal Mining Office at Breslau were as follows, the quotations being marks (23·8c.) per 50 kg.

	1894.	1895.	1896.	1897.	1898.	1899.	1900.
First quarter.....	14·50	12·50	13·50	16·00	16·50	25·00	20·00
Second quarter.....	14·00	13·00	15·50	15·50	17·50	26·00	20·00
Third quarter.....	14·00	13·50	15·50	15·50	19·00	22·50	18·00
Fourth quarter.....	13·00	13·50	11·00	16·50	22·00	19·50	17·50
Average.....	13·87	13·12	15·12	15·87	18·75	23·25	18·87

In Upper Silesia there were 24 works in operation during the year.

The sheet business was satisfactory and there were no accumulations of stocks at the end of the year notwithstanding the increased output. The demand was rather unsteady at times owing to the falling prices. In the domestic market the decreased consumption in the building trades was made up by the larger requirements of the Government for the army and navy. Export trade suffered from the complications in South Africa and China, high ocean freights and the competition of the United States. The price of sheet zinc was 50 marks per 100 kg. at the opening of the year, rising to 53 marks in May and closing at 46 marks. The output was 38,467 metric tons, against 35,646 tons in 1899. All the manufacturers of sheet zinc in Germany have agreed to sell through a common agency.

The zinc white business was satisfactory during the first half of the year, as the works were busy filling old contracts. Later, there was a weakening in the trade and prices showed a tendency to follow the downward course of the spelter market. Manufacturers aimed to improve the conditions by limiting their output, but at the close of the year the prospects for the future were not encouraging.

A Review of Progress in the Metallurgy of Zinc in 1900.

By Walter Renton Ingalls.

Economic Conditions.—Certain commercial and technical changes of great importance occurred in the American zinc industry in 1900. One of these was the predominance which the natural-gas smelters of Kansas gained decidedly over those who are dependent on coal fuel. The other was the rapidly increasing supply of Colorado zinc ore. Both these developments affected the zinc producers of the West rather than those of the East.

The chief points for smelting the ore of the Joplin district used to be Lasalle and Peru in Illinois, St. Louis, Mo., and the vicinity of Pittsburg, Kan. Lasalle, Peru and St. Louis were zinc smelting centers before the Joplin mines were worked for zinc. Pittsburg, Kan., owed its development to the productive coal measures over which it is built, and being only 26 miles from Joplin, with excellent railway connections, it became naturally an advantageous place for smelting the ore mined at and near Joplin. About 5 years ago the natural gas supply in the vicinity of Iola, which by railway is approximately 100 miles from Joplin, began to be used for zinc smelting, and since then numerous works have been erected at that point. The experience has demonstrated that zinc ore can be

smelted more cheaply at Iola, under the conditions which exist there, than at Pittsburg, Kan., and gradually the coal smelteries have been closed, though this result did not take place in a marked degree until 1900. In 1899 the conditions of the ore and spelter market were such that even the Iola smelters were unprofitable. With 1900 the unfavorable conditions were ameliorated, but the increasing competition of the Iola smelteries, of which the largest had previously been consolidated in strong hands, prevented the price of ore from falling to the former level, and few of the coal smelters of Kansas and Missouri were able to meet the new prices, especially under the further disadvantage of the increased price for coal which prevailed in 1900. The coal smelters of the Lasalle-Peru and St. Louis districts, however, because of the magnitude of their works, good management and other advantages, have been able to withstand the competition of the Iola works.

With respect to the new supply of zinc ore from Colorado, it has been known for many years that the State possessed vast resources of mixed sulphide ore, most of it argentiferous, and some of it rather high in zinc, but still mixed with sufficient lead and iron to make it undesirable material for the zinc smelter.

In 1899 and 1900 some of the smelters of Kansas and Missouri purchased a considerable quantity of such Colorado concentrates as were better than the average, but the chief trade in that material has been developed with smelters in Wales and Belgium, who entered the market in 1899 and in 1900 bought largely. This trade has been made possible by the favorable freight rates which have been obtained, the ore being carried from Leadville via Galveston to Swansea or Antwerp at a cost of less than $10 per ton of 2,000 lb. The miners receive comparatively little for the material, $5 per ton being the usual price, but inasmuch as their zinc concentrates are purely a by-product and the value of the remainder of the ore is increased by their removal, the miners can very well afford to sell them even at so low a price. The fact that a market for such material has been established excited general attention in Colorado, and steps were taken to increase the milling capacity. At the same time experiments were made with the Wetherill magnetic separator and other special processes with a view to the more profitable development of the State's zinc resources.

Otherwise the American zinc industry in 1900 was without special feature. No new smelting works were erected, although it is understood that several are contemplated; nor were any important additions made to the capacity of existing works, which have already in the aggregate an ability to smelt more ore than is mined in the United States, and can produce more spelter than is required in the United States at the present rate of consumption. The latter fell off greatly in 1900 and although production also fell off, there was a great surplus in the spelter product of the United States, which the smelters were fortunately able to export to Europe at satisfactory prices, and the shipments abroad attained a phenomenal figure. Such smelters in Kansas and Missouri as continued to use coal were unhampered by labor difficulties on the part of the coal miners, which frequently caused trouble in previous years; the use of natural gas has to a large extent freed the smelters from that factor of uncertainty.

The employees of the Matthiessen & Hegeler Zinc Co., at Lasalle, Ill., struck for higher wages in May and as a consequence thereof the works of that company were idle for a considerable period during the early summer.

Zinc Mining in the Joplin District.—Harold A. Titcomb described the conditions of mining in the Joplin district,* where operating mines on leased land is almost a universal practice. Under that system, the landholder usually gives a lease on a large tract of land at a royalty of from 8 to 15% of the gross output of mineral, the lease being made commonly for a period of 10 years. The lessee prospects the tract by drilling or sinking shafts and if mineral is found, subleases portions of the property, usually lots of 200 ft. square, at a royalty of 15 to 25% of the gross output of mineral. In some cases the fee-holder operates his own mines and frequently a prime lessee prefers to work a rich deposit rather than to sublease it. This system has at least one good result, inasmuch as it makes the district largely free from labor difficulties, so many miners being directly interested in the operations. Experience has shown also that in the long run the system is probably the most economical under the conditions which exist in the Joplin district, since although a company operating its own property on a large scale can mine and mill most cheaply, lessees are at an advantage in exploring for new ore bodies.

Mining is done in the Joplin district from the grass-roots down to 250 ft., the average depth of all the shafts operated being about 120 ft. Many drill-holes have recently been put down to depths of from 250 to 300 ft. and more and have disclosed rich ore. The contract price of drilling to ordinary depths is $1·25 per foot, but better figures can be obtained on large contracts. Owing to the shattered condition of the rock formation and the presence of chert in irregular and broken masses, the diamond drill has not been successful in the Joplin district. The cost of shaft-sinking is very variable, depending on the locality and kind of ground. A 6×7-ft. shaft was sunk 80 ft. on contract in the Belleville district for $2 per foot; this shaft was in soft open ground. A 5×7-ft. shaft 70 ft. deep, 2 miles west of Joplin, cost $20·25 per foot, this figure including a small boiler and pump. A shaft 125 ft. deep was sunk 1 mile west of Joplin at a cost of $14·30 per foot, 90 ft. being in hard flint and limestone and 35 ft. in open ground.

The customary steam concentrating mill costs $6,000@$8,000 for 100 tons capacity per 10 hours. Such a mill will actually treat about 50 to 80 tons per 10 hours, depending on the character of the ore. A hard flint ore is brittle and easily passes through the crusher, while a clayey ore chokes up the machinery and diminishes the capacity of the mill.

Purchase of Ore in the Joplin District.—W. George Waring described the present method of purchasing zinc ore in the Joplin district.† It is customary to deduct 50c. per ton for each unit of lead in the ore and $1 for each unit of iron in case the ore assays more than 1% Fe. The smelting charges include commissions, carting, freight and cost of smelting, which are lumped at $10·50 per ton of ore. To this is added a margin of profit varying from $4@$8 per ton when spelter is quoted in St. Louis at 4c. per pound, or from

* *Engineering and Mining Journal*, July 28, 1900. † *Ibid.*, July 14, 1900.

$6@$12 per ton when the spelter quotation is 6c. per pound. The nominal cost of $10·50 per ton is applied equally to low and high grade ores, and the margin of profit is increased in the case of low grade ores to cover extra loss and expense incurred in reducing them.

The formula at present applied by the principal smelters to the valuation of ores is:

$$V=WQ—(E+P),$$

in which

W=80% of the number of pounds of zinc contained in a ton of the dry ore as found by assay; if the assay be A, then W=16A.

Q=the St. Louis spelter quotation per pound at time of purchase.

E=expense, freight and treatment cost ($10·50).

P=smelter's profit, etc.=100Q when A=60% or over; when A is less than 60%, P=100Q+(10Q×60—A).

V=value of ore at mine, subject to deduction for iron or lead contents.

Allowing 20% for loss, the total smelting charges upon 60 to 65% ore vary from $13·50@$16·50 per ton, and upon 50% ore from $16·50@22·50 per ton, according as the price of spelter varies from 3@6c. per pound.

The system of sampling employed consists in taking a few shovelfuls of the moist jig stuff when it has been loaded in the railroad car, which are mixed together and quartered down to from 1 to 5 lb. This is divided into three parts, in the presence of seller and buyer, one part being given to each party and one reserved against accident, or disagreement. Each party has his sample assayed, and unless a variance of more than a few tenths of 1% appears, the average of the certified results is taken as the basis of settlement. Moisture is determined in the usual manner. The percentage in jig stuff, when ready for shipment, varies from 1 to 4, according to the quantity of fine material it contains. Buddle, or sludge headings, when fresh, carry from 10 to 12%, and fine sludge concentrates from 12 to 17%. The selling of zinc ore in the Missouri-Kansas district upon an assay basis has led to a steady improvement in the grade and value of the ore produced by miners who sell entirely upon assay, and have occasional analyses made of their jig products in order to control the mill work.

Carbonate ores (dry bone) are mined by stripping along the southeastern outcroppings of the zinc ore ranges, where the lower zinc bearing strata come to the surface. They are sold for $10@$15 per ton, delivered at the railroad. Their zinc contents range from 40 to 48%, and although these ores are mined usually in well wooded regions, and often many miles from the railroad, they are never calcined before shipment. The advantage of calcining on the ground, in stalls or kilns or even in heaps, seems to be persistently ignored, although this inexpensive procedure increases the zinc percentage about 30% and saves 25% in freight. Carbonate ores are not, as yet, sold upon an assay basis.

Cost of Coal in Europe.—The report of the Société Anonyme de la Vieille Montagne, for 1900, presented data as to the extent to which the recent rise in the value of coal in Europe has affected the zinc smelters there. The establishments of that concern in Belgium, Germany and France consumed 494,945 metric tons of coal in 1900, which cost 8,469,377 fr., or an average of 17·11 fr. ($3·30)

per ton, against 471,285 tons, costing 6,414,166 fr., or an average of 13·61 fr. ($2·63) per ton in 1899. The increased cost of coal to that company last year was consequently 2,055,211 fr. During the last five years the cost of coal has been steadily advancing, the average cost of the consumption of the Vieille Montagne Co. having been 10·52 fr. ($2·03) per ton in 1896; 11·17 fr. ($2·16) in 1897; 11·92 fr. ($2·30) in 1898; 13·61 fr. ($2·63) in 1899 and 17·11 fr. ($3·30) in 1900. At the same time the quality of the coal has been deteriorating so that an increased quantity has been required to do the same work. The result has been that the increased cost of coal in 1900 as compared with 1899 was equivalent to a deduction from the dividends of the company to the extent of 18·27 fr. per share; and in the five years 1896-1900, both inclusive, to 35·04 fr. per share.

The increase in the cost of coal has been the greatest in Belgium, but it is there unfortunately that the most and largest of the works of the Vieille Montagne Co. are situated. In 1900 the average cost of the coal used by the Belgian smelteries was 18·19 fr. ($3·51) per metric ton, against 9·96 fr. ($1·92) in 1896; at the German smelteries the corresponding figures were 12·41 fr. ($2·40) and 10·13 fr. ($1·96), and at the French smelteries 11·63 fr. ($2·24) and 9·62 fr. ($1·86). Considering that in the best practice in France, Belgium and the west of Germany from 3 to 4 tons of coal are required for the production of one ton of spelter from calamine containing 50% Zn the increased cost per pound in the production of spelter in western Europe can easily be reckoned. At the end of 1900 contracts for a part of the Vieille Montagne requirement for coal were renewed at the rate of 22 fr. ($4·25) per metric ton, a price which has been pronounced disastrous. Under these circumstances it is not surprising that the company should be looking for mines to provide its own supply of coal, and has already acquired coal lands near one of its French works.

ANALYTICAL METHODS FOR THE DETERMINATION OF ZINC.—The potassium ferrocyanide method for the determination of zinc volumetrically continues to be the standard in the United States, and in points of rapidity and accuracy leaves little to be desired. The technical literature of 1900 contained several important papers touching upon this method.

*Albert H. Low** described the von Schultz & Low method in its latest development. The solution of potassium ferrocyanide is prepared by dissolving 22 g. of the crystals in one liter of water. In order to standardize it 100 mg. of pure zinc are dissolved in 6 c.c. of strong hydrochloric acid, using a 400 c.c. beaker. About 10 g. of ammonium chloride and 200 c.c. of boiling water are then added. This solution of zinc is titrated with the ferrocyanide until a drop tested with a drop of a strong solution of uranium nitrate shows a brown tinge. Instead of using a single drop of the zinc solution, the reaction is much sharper if several drops be placed in a depression of the plate and tested with a single drop of the uranium solution. The end-point is usually passed by a test or two and the reading of the burette must be corrected accordingly; a further correction must be made for the quantity of ferrocyanide required to produce a tinge under the same conditions when no zinc is present.

In determining zinc in an ore, 0·5 g. of ore is treated in a 250 c.c. pear-shaped

* *Journal of the American Chemical Society*, Vol. XXII., No. 4, p. 198, April, 1900.

flask with about 2 g. of potassium nitrate and 5 c.c. of strong nitric acid. The flask is heated until the acid is about half gone, when 10 c.c. of a cold saturated solution of potassium chlorate in strong nitric acid is added and the contents of the flask are then boiled to complete dryness. It is usually necessary to manipulate the flask in a holder over a naked flame to avoid loss by bumping. The potassium nitrate serves simply as a diluent of the dry residue and insures the completeness of the subsequent extraction of the zinc.

After evaporation the flask is cooled and 30 c.c. of a prepared ammoniacal solution is added and heated to boiling. The ammoniacal solution is made by dissolving 200 g. of ammonium chloride in a mixture of 500 c.c. of strong ammonia water and 350 c.c. of water. After gentle ebullition for about two minutes, the contents of the flask are poured on a 9-cm. filter and the precipitate washed with a hot solution of ammonium chloride containing about 100 g. of the salt and 50 c.c. of strong ammonia water to the liter. The insoluble residue should be completely disintegrated and any ferric hydroxide present should appear of a fine sandy nature. The filtrate should be collected in a 400 c.c. beaker, and having been tested by a bit of litmus paper (not necessary if much copper be present) should be neutralized carefully with chlorhydric acid, an excess of 6 c.c. of the strong acid being finally added. After dilution to about 150 c.c. and addition of 50 c.c. of a cold saturated solution of hydrogen sulphide, and heating nearly to boiling the solution is ready for titration. If more convenient or apparently advisable, a current of hydrogen sulphide gas may be passed through the hot solution diluted to 200 c.c. Copper and cadmium are thus precipitated. Unless in large amount they need not be filtered off, since the discoloration of the liquid by as much as 10% Cu does not mask the uranium test.

In titrating the hot solution about one-third should be poured off and set aside in a beaker. The remainder may be titrated more or less rapidly until the end-point is passed. The greater part of the reserved portion should then be added and the titration proceeded with more carefully until the end-point is again passed. Finally the last reserved portion should be added and the titration finished two drops at a time. The true end-point is always passed slightly, but after waiting a minute it is usually sufficient to deduct for as many drops as show a brown tinge and one test additional.

E. H. Miller and E. J. Hall investigated the influence of various substances likely to be present when zinc is estimated by titration with potassium ferrocyanide and uranium acetate is used as indicator, such substances being added in successively increased quantity to constant known amounts of zinc solution which were titrated with ferrocyanide of a definite strength, uniform conditions of temperature and volume being carefully maintained. The following conclusions were drawn: (1) Salts, such as calcium chloride and sodium citrate, and acids, especially hydrochloric, disturb the end reaction by their solvent effect on uranium ferrocyanide. (2) Zinc ferrocyanide diminishes this effect in the case of hydrochloric acid; the correction established from blank tests is therefore slightly too great. (3) Ammonium chloride, not exceeding 17 parts, does not affect the accuracy of the method, but has some unknown action on zinc ferrocyanide. (4) Aluminum sulphate, in considerable quantity, renders the results unreliable.

(5) Twelve parts of concentrated hydrochloric acid, sp. gr. 1·2, suffice to prevent interference by lead. (6) Antimony gives high results, but small quantities of bismuth have no influence.*

R. K. Meade described a method for determining zinc by titration with a standard solution of sodium thiosulphate. Manganese is first thrown down as dioxide by means of potassium chlorate and nitric acid. After filtering, the iron and alumina are separated by double ammonia precipitations. Calcium and magnesium are removed by the addition of a large excess of sodium arsenate, and then the zinc is precipitated by adding nitric and acetic acids. The iodine liberated by digesting this precipitate in an acid solution of potassium iodide is titrated with standard thiosulphate and the amount of zinc calculated. The time required for four determinations, without any effort at speed, was about eight hours. The ore tested contained 30·18% Zn; the method described gave 30·00, 29·98, 30·04 and 29·98%.†

W. Euler described a method for the gravimetric determination of zinc as sulphate.‡ The solution of the zinc salt (which must not contain any acid that cannot be volatilized when heated with sulphuric acid) is evaporated in a tared, covered platinum crucible with addition of an excess of dilute sulphuric acid. The crucible is heated very gently around the upper edge by a ring burner until the excess of sulphuric acid has been driven off; then the temperature is raised for five or ten minutes, so that the upper third of the crucible is kept red-hot. When the weight remains constant, the zinc is quantitatively converted into the anhydrous sulphate. By way of control, the crucible may be heated to whiteness over the blowpipe till the sulphate is completely converted into oxide. This method does not appear to offer any advantages.

A. Fraenkel described a modification of his former method for the valuation of zinc dust, in which there was difficulty in ascertaining the end-reaction, caused by the deep color of the solution. The modified method is as follows: About 1 g. of the sample is weighed into a dry, well-stoppered flask of 200 c.c. capacity, and treated with 100 c.c. of a semi-normal solution of potassium bichromate and 10 c.c. of dilute sulphuric acid (1 to 3). The mixture is shaken for five minutes, then 10 c.c. more of the acid are added, and the mixture is again shaken for from 10 to 15 minutes. The zinc by this time will have entirely dissolved. The solution is transferred to a half-liter flask and diluted to the mark, 50 c.c. of it are taken and after the addition of 10 c.c. of potassium iodide solution (1 to 10) and 5 c.c. of sulphuric acid are titrated with decinormal sodium thiosulphate solution.§

PHYSICAL PROPERTIES OF ZINC.—With respect to the physical properties of zinc the most important contribution to scientific knowledge in 1900 was an accurate determination of the boiling point of the metal.

Saturation Point of Zinc-Lead Alloys.—E. Heyn contributed a discussion‖ upon the theory of the separation of lead from spelter. He analyzed the data

* *Columbia School of Mines Quarterly*, 1900, 21, (3), 267–272.
† *Journal of the American Chemical Society*, 1900, 22, (6), 353–356.
‡ *Zts. Anorg. Chem.*, 25, 146; and *Chem. Zeit. Rep.*, 24, (74), 266.
§ *Mitt. des k. k. techn. Gewerbe Museums in Wien*, 1900, 10, (7 and 8), 161–162.
‖ *Berg- und Hüttenmannisch e Zeitung*, LIX., 47, p. 559, Nov. 23, 1900.

obtained by Spring and Romanoff concerning the solubility of lead and zinc at various temperatures, which are given in the following table:

Temperature. °C.	Lower Stratum.		Upper Stratum.	
	% Pb.	% Zn.	% Pb.	% Zn.
334	98·8	1·2		
419			1·5	98·5
450	92·0	8·0		
475	91·0	9·0	2·0	98·0
514	89·0	11·0	3·0	97·0
584	86·0	14·0	5·0	95·0
650	83·0	17·0	7·0	93·0
740	79·0	21·0	10·0	90·0
800	75·0	25·0	14·0	86·0
900	59·0	41·0	25·5	74·5

This table shows how the percentage of lead alloyed with the zinc increases with the temperature. At a point 2 or 3°C. above the melting point of zinc the latter still retains 1·5% Pb. In refining lead-bearing zinc by gravity it is therefore impossible to go below that figure. In practice the separation between the lead and zinc is somewhat affected by the presence of iron in the crude zinc, but the precise effect of that impurity has not been determined.

Boiling Point of Zinc.—The precise boiling point of zinc has heretofore been uncertain, various determinations of which record is to be found in metallurgical treatises ranging from 891°C. (Becquerell) to 1,050°C. (Komorek). The most authoritative figure was that obtained by Roberts-Austen with the Le Chatelier pyrometer, namely 940°C., and since reported it has been commonly adopted. Last year a redetermination was made by D. Berthelot.*

The metal was contained in a deep narrow porcelain crucible, surrounded by a nickel wire, which when traversed by an electric current constituted the source of heat. The apparatus was packed in magnesia and asbestos to prevent radiation. The temperature was measured by a thermo-couple contained in a porcelain Rose's tube sealed at the end, this tube passing through the cover of the crucible, which was fitted moreover with other tubes by which a stream of nitrogen gas was passed through. The molten metal was kept at a temperature 2 or 3°C. below its boiling point until uniformly heated, after which the current was slowly increased. The temperature rose to the boiling point and then remained steady in spite of further increase of the heating current. Five determinations gave results varying from 913 to 927°C., the arithmetical mean of the extremes being 920°C. This result, which will no doubt be generally accepted, agrees closely with the figure reported by Violle, namely 929·6°C. Berthelot also determined in a similar manner the boiling point of cadmium, three experiments with an extreme range of 8°C. giving a mean value of 778°C.

Magnetic Concentration of Zinc Ore.—A Wetherill magnetic separating plant installed at Lohmannsfeld in the Siegen district in Germany was described by M. Smits in a paper read at the International Congress of Mining and Metallurgy at Paris in 1900.† This plant was designed to separate blende and siderite containing from 15 to 22% Zn, which was obtained as a middlings product from the wet dressing works. The ore is dried by passage through a

* *Comptes Rendus*, 131, (6), pp. 380–382; *Journal of the Society of Chemical Industry* Oct 3, 1900.

† *Engineering and Mining Journal*, Oct. 20, 1900, p. 459.

steam-jacketed screw conveyor and is then crushed to pass a 3-mm. screen and divided into four sizes. The dry screened ore is passed over Wetherill magnetic machines of the 2-pole and 3-pole types, arranged two in a series. In the upper member of each spathic iron is separated by a light current; what passes as diamagnetic product is delivered to the lower member, whereof the intensity of the magnetic field is greater; this yields a mixture of blende and spathic iron as paramagnetic product and pure blende as diamagnetic. The edges of the poles are 34 cm. wide; the speed of the carrying belt is 40 m. per second for the upper and 25 m. for the lower. The tension of the current is 65 volts. The upper machine of the 2-pole type works with 12 amperes and the lower with 14 to 16 amperes, while for the 3-pole machines the corresponding figures are 5 and 8 amperes. With eight men the plant separates from 3 to 3·5 tons of raw ore per hour, at an average cost of 1·4 mark (29c.) per metric ton of crude ore, not including interest, amortization, or repairs and renewals.

DISTILLATION.—There was no change in the practice in distillation in 1900, but some interesting experimental work, confirming former theories, was reported and one new proposal was made that attracted considerable attention.

Influence of Sulphur in the Charge.—E. Prost described a series of experiments which were made to ascertain how far an incomplete desulphurization in roasting affects the percentage of zinc recoverable from blende. He investigated two different samples of ore, one rich in lead (10%) and containing 19% S; the other containing 15% Fe and 30% S. After dead roasting, these ores contained 2·10% S and 2·91% S, respectively; samples drawn from the furnace eight hours before the completion of the roasting showed 5·33% S and 7·73% S, respectively. In distilling 125 kg. of each of these samples, mixed with 85 kg. of lean coal, in alternate retorts of the same row in a furnace the percentages of the total zinc originally present held by the residues were found to be as follows: In the imperfectly roasted plumbiferous blende, 7·38%; in the completely roasted plumbiferous blende, 1·35%; in the imperfectly roasted ferruginous blende, 6·70%; in the completely roasted ferruginous blende, 0·95%. The importance of complete roasting was thus demonstrated. In the case of ferruginous material, the smaller loss of zinc indicated the favorable influence of iron in displacing that metal from combination with sulphur. It was also found that the completely roasted ferruginous blende contained a larger proportion of soluble sulphates than the incompletely roasted sample, indicating an important decomposition of ZnS, in the last stage of the roasting.* The smallness of the loss of zinc even in the worst roasted sample was remarkable.

Effect of Calcium and Barium Sulphates in the Charge.—W. George Waring called attention to the fact that a marked difference in actual yield in smelting often exists between ores of the same grade, although the calcination and distillation may be exactly alike in both cases.† He considered that the difference is probably due to the presence of lime or baryta existing in the ore originally as sulphates, or being formed as sulphates during the calcination process, which in

* *Bull. Assoc. Belge de Chim.*, 14, (3-4), 125-131; *Journal of the Society of Chemical Industry*, Aug. 31, 1900; *Revue Univers. des Mines*, XLIX., 3, p. 247, March, 1900.

† *Engineering and Mining Journal*, July 14, 1900.

the retort appear to yield their sulphur, in part, or wholly, to the zinc, rendering the latter incapable of reduction to the metallic state. He mentioned that several quantitative tests made by him showed that one part of lime contained in blende ore, as carbonate, will combine with and retain in calcination from 0·4 to 0·7 part of sulphur, and reported that it was estimated from practical tests on a large scale, at one of the principal Western zinc smelteries, that one part of lime in blende ore entails a loss of two parts of metallic zinc in smelting, over and above the ordinary losses. The Joplin ore is dressed so cleanly, however, rarely containing more than 8% of gangue (flint, calcite, and rarely barite) and sometimes as little as 3%, that the assay is a rather reliable guide as to the value of the ore, especially since the customary deduction for loss in smelting is one-fifth of the total zinc contents of the ore. John E. Williams criticised* Waring's theory as to the loss of zinc in distillation caused by the sulphur that remains as sulphates of the alkaline earths after calcination of the blende. He considered it unlikely in view of the reaction of lime on sulphide of zinc that calcium sulphate could react as indicated by Waring. Williams referred to experiments made by him at a smeltery in Kansas, whereby it was proved that the common statement that one unit of sulphur remaining combined with the zinc in a roasted ore will retain two units of that metal in distillation, is correct; and moreover that either lime or iron oxide will react in the retort with the sulphur of an imperfectly roasted blende and liberate metallic zinc.

The reactions which take place in the retort are very complex and with our present knowledge it is difficult to determine precisely what happens. Many chemical actions that occur are too slow to be of practical value. Zinc sulphide itself appears to be to some extent reducible by carbon and there is no doubt that lime and iron have a decomposing effect upon ZnS. It was an old theory that calcium or barium sulphate in the retort would react with zinc vapor and produce zinc sulphide, but the recent experiments of Prof. Prost appear to have demonstrated that no such danger is to be feared. The old rule that one unit of sulphur will hold back two units of zinc is a safe guide.

Grate for Belgian Furnaces.—John D. James, of Pulaski, Va., patented a grate for use with direct-fired Belgian zinc distillation furnaces. His improvement consists in placing a water pipe in the plane of the grate bars, resting on the grate bearers between the grate bars and the side walls of the firebox. Water is circulated through this pipe around the grate, the flow being controlled by suitable valves. The water pipe has perforations on its upper side so as to discharge fine jets of water into the bed of ashes resting upon the bars, making it easier to remove the clinkers and reducing the temperature in the ash pit.†

Chapman's Furnace Shield.—Charles S. Chapman, of the Pittsburg Foundry and Machine Co., of Pittsburg, Kan., patented a shield for zinc distillation furnaces.‡ It is essentially a pair of vertical plates of sheet iron or steel, arranged with a ladle between them, which can be moved longitudinally along the façade of the furnace. (See Figs. 1, 2, 3 and 4.) Each side of the furnace is fitted

* *Engineering and Mining Journal*, July 28, 1900.
† United States Patent No. 643,507, Feb. 13, 1900.
‡ United States Patent No. 654,516, July 24, 1900.

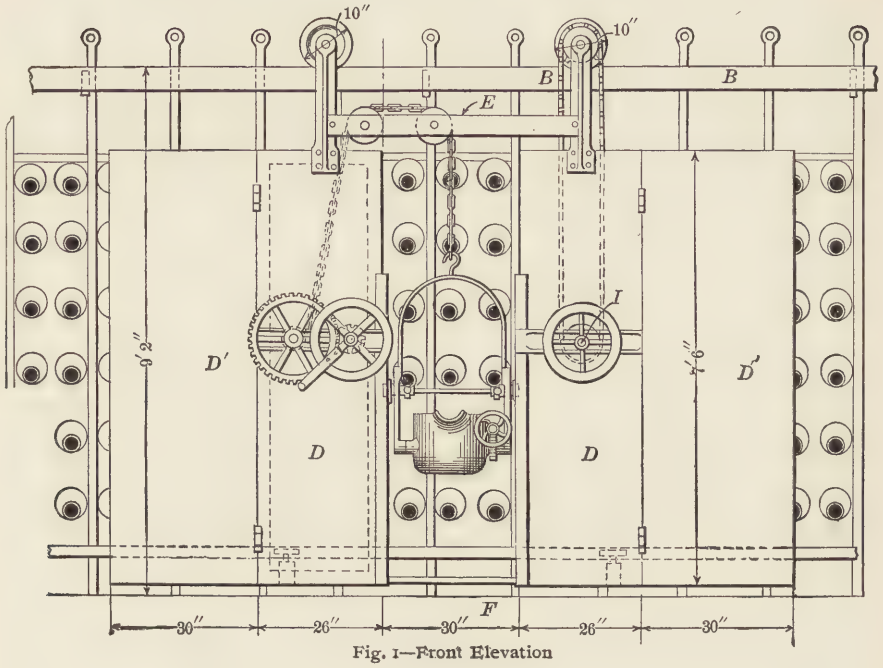
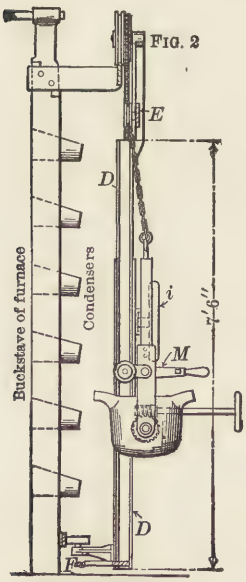
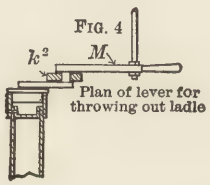
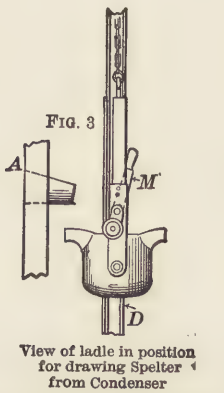


Fig. 1—Front Elevation







FIGS. 1, 2, 3 AND 4.—CHAPMAN FURNACE SHIELD.

with a longitudinal track supported by brackets which are bolted to certain of the buckstaves, above the uppermost row of retorts. On this track run two grooved wheels with hangers which carry the shield. The axle of one of these wheels is fitted with a sprocket to receive a chain for moving the apparatus. The shield consists of two plates 30 in. apart and stiffened by angle iron; each plate is provided with a wing hinged to it, forming extensions of the shield. The hangers are bolted to a horizontal bar *E* and the lower ends of the plates *DD* are held in proper position by means of a bar *F* which is curved inward toward the furnace in order that it may not interfere with the ladle. Bolted to the buckstaves near the bottom of the furnace and extending the whole length of the latter is a guide-rail, having a vertical outer face, and the plates *DD* of the shield are fitted with brackets carrying rollers which bear against the guide-rail and steady the lower ends of the plates when the shield is moved longitudinally along the furnace. The weight of the shield tends to throw its lower part inward toward the furnace, wherefore the rollers are always in contact with the guide-rail. One of the plates of the shield is fitted with a horizontal shaft *I*, carrying a hand-wheel and a sprocket; the latter being connected by a chain with the sprocket of the corresponding grooved wheel running upon the upper rail, the shield can be moved by means of the hand-wheel in either direction along the furnace.

Between the two main plates of the shield is arranged a ladle, provided with a spout on its inner and outer sides and trunnions which rest in the lower ends of two vertical arms. The upper ends of these arms are connected by a bail, from the hook of which the ladle is suspended by a chain. This chain passes over a sheave on the horizontal bar *E*, and thence over another sheave on the same bar down to a windlass which is fixed in the framework of one of the plates of the shield. By means of this windlass the ladle can be raised and lowered. In order to guide the ladle in its vertical movements there are rollers placed on the ends of a bent lever *M*, which rollers engage in vertical grooves on the inner edge of each plate *D*. The lever *M* is pivoted on the hangers by which the ladle is suspended, forming a toggle joint. By pulling down the lever the ladle is thrust outward, so that it will avoid the ends of the condensers, when it is raised and lowered. One of the trunnions of the ladle is provided with a worm-wheel and the adjacent hanger has a worm-shaft with a hand-wheel at its outer end. By means of this device the ladle can be tilted to pour its contents into a mold or other receptacle. The ladle can be disconnected from the suspending chain and removed so that the shield can be used without it for such work as taking down the condensers and cleaning out the retorts, when the ladle is not needed and would be in the way.

Furnace shields of this type are used in connection with the long natural-gas fired distillation furnaces which are employed at Iola, Gas City and Cherryvale, Kan. On account of the great heat to which they are subjected roller bearings are employed largely in their construction. The ladle holds about 400 lb. of metal. The shields cost $125 apiece, not including the tracks, f. o. b. Pittsburg, Kan., and weigh approximately 1,500 lb.

Non-Corrosive Retort Lining.—Benjamin Sadtler, of Denver, Colo., patented a zinc retort which consists of the ordinary cylindrical vessel of refractory

material, provided with a basic lining about 0·125 in. in thickness. As basic material, magnesia, chromite, corundum, or titaniferous iron ore, may be used; no special claim is made to any particular substance. This lining is prepared by application of a solution of sodium silicate to the interior of the retort, after which the refractory material pulverized to pass a 20-mesh sieve, or about that size, and free from fine dust is introduced, and by rotation of the retort in a suitable framework is made to adhere to the inner walls as an even coating. When the retort is burned in the ordinary manner the sodium silicate sinters with the clay of the retort on the one hand and the coating of refractory material on the other and produces a firm and dense lining, which is claimed to resist the corrosive influence of high percentages of iron, manganese, etc., which would be fatal to distillation in an ordinary clay retort. By the use of the retorts above described the inventor proposes to treat the mixed sulphide ores of Colorado and elsewhere by roasting and distillation and patents have also been taken out on that process. These patents excited a good deal of interest last year in the Western States where large deposits of that class of ore exist.

A furnace to demonstrate the utility of the Sadtler retorts was erected at Denver and ran for a brief campaign, as to which Mr. Sadtler communicated the following results:*

Two separate runs were made, one of 89 consecutive days, the other of forty-two. The furnace contained 30 retorts of the regular size, which were purchased in Missouri. They were lined with various basic substances. In the run of 89 days a loss of 10 retorts was experienced, all of which was by breakage, none being corroded. The total loss was equivalent to a daily loss of one in 267. The ore which was smelted assayed before roasting from 16 to 30·5% Fe, from 1·5 to 12·89% Pb, from 2 to 9% SiO_2 and from 16·5 to 37·5% Zn, its silver content varied between 5 and 17 oz. per 2,000 lb.; its gold content ran from $1 to $11 per 2,000 lb. The spelter which was produced assayed from 0·52 to 1·12% Pb and from 0·06 to 0·12% Fe; it was free from gold and silver. The residues drawn from the retorts assayed from 4·2 to 8·5% Zn and contained all of the gold, silver, copper and iron originally present in the ore and practically all of the lead. In the second run of 42 days the residues assayed only 5·4% Zn. The recovery of zinc ranged from 70 to 84% and was irregular because the temperature of the small furnace could not be governed properly. The ores treated were not roasted so low as 1% S, but notwithstanding that the percentage of zinc retained by the residues from the retorts was very low. This is attributed to reduction of metallic iron, which decomposed the imperfectly roasted blende and liberated its zinc. A good deal of iron shot and some large pieces of metallic iron were found in the retort residues. This iron contained a noteworthy quantity of the precious metals, especially gold. The cost of lining the retorts is from 8 to 12c. apiece.†

ELECTROGALVANIZING.—S. Cowper-Coles described certain experiments, which were undertaken to determine the adhesiveness of zinc to steel, when deposited

* *Engineering and Mining Journal*, Sept. 29, 1900.

†United States Patent No. 642,722, Feb. 6, 1900; No. 656,268, Aug. 21, 1900. English Patent Nos. 1892, 1893 and 1894, all of Jan. 30, 1900.

under varying conditions as to preparation of the steel plates, acidity of the electrolyte, and current strength. Specimen plates of mild Sirna steel received a careful preliminary treatment, and were then coated with zinc at current densities varying from 15 to 30 amperes, advancing 5 amperes at a time, for a sufficient time to allow a calculated deposit of 1·25 oz. per sq. ft. They were then subjected to tests, which showed that the zinc coating was not adhesive. In another series of experiments the plates were treated in exactly the same way with the exception that before galvanizing they were placed in the zinking bath, and the current caused to flow in the opposite direction to that required to deposit zinc

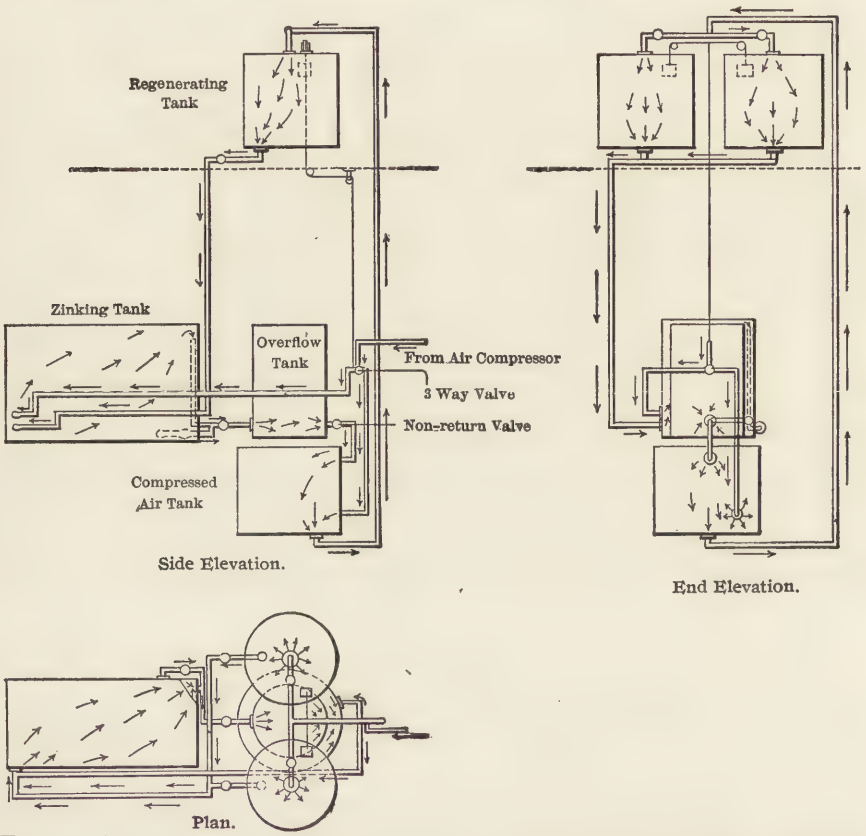


FIG. 5.—DIAGRAM OF ARRANGEMENT OF AN ELECTRO-GALVANIZING PLANT.

upon them, for a period of 2·5 minutes; the current was then reversed and the zinc deposited as described above with the result that it was found to be adhesive; there was very little difference between the general appearance of the deposits in the two cases. The electrolyte contained 35 oz. of zinc sulphate per gallon, the acidity being about 0·2 oz. of free sulphuric acid per gallon. Another set of experiments was made to determine the cause of the non-adhesion of zinc deposited on iron from neutral solutions of zinc sulphate, under which condition the deposits were smoother and more even, but non-adhesive, this being attributed to the formation of a film of oxide on the iron plate when it is first immersed in

the electrolyte. Cowper-Coles thinks that the best deposits of zinc can probably be obtained by using neutral zinc solutions, and, after placing the cathode in the bath, momentarily reversing the current, so as to remove the film of oxide formed and thus secure an adherent deposit.*

Electrogalvanizing is now being used extensively for the protection of boiler tubes in England and on the Continent, the British admiralty specifying that all boiler tubes be protected externally with a coating of zinc equal to 1·25 oz. per sq. ft., and that economizer tubes be coated inside and outside with an equal thickness. The Cowper-Coles process has proved one of the most successful of the electro-galvanizing systems that have come into use. A new Cowper-Coles regenerative plant was erected in 1900 for the Germania Shipbuilding and Engineering Co., at Tegel, near Berlin, for the coating of boiler tubes, such as are used in the Thornycroft and Yarrow water-tube boilers. The plan of arrangement is shown in Fig. 5. It was equipped with a dynamo capable of giving 3,000 amperes at 6 volts, and direct coupled to a three-phase motor, which is provided with a pulley for driving a small air compressor, used for circulating the electrolyte. The electric current is conveyed to the depositing tank by means of bare copper strips. The switchboard is provided with ammeter, voltmeter, and main switch; a resistance has been found to be unnecessary. The circulation of the electrolyte is effected in the following manner: The acid solution falls over a wooden sill placed in one corner of the zinking tank into an overflow tank, and then flows into a compressed-air tank. When air is blown in, the solution is forced up into the regenerating tanks; a non-return valve is placed in the pipe connecting the overflow tank to the compressed-air tank to prevent the air escaping into the zinking tank. The supply of air to the compressed-air tank is regulated by means of a three-way cock actuated by a float placed in the regenerating tank in such a manner that when the air is cut off from the compressed-air tank, it is blown through the solution in the zinking tank, thus keeping it agitated. Zinc dust, mixed with finely divided coke or sand, is placed in the regenerating tanks on wooden grids, covered with cocoa matting, so as to form a filter bed and at the same time regenerate the electrolyte. The regenerated electrolyte is returned to the zinking tank.

The electrolyte contains 35 oz. of crystallized zinc sulphate to the gallon of water. In practice it is found very important to keep the zinking solution slightly acid, otherwise the zinc coating will not be adhesive, and will have a tendency to blister. The best proportion of free sulphuric acid is about 0·1 oz. to every gallon of water. The free acid in solution is quickly determined by using capsules of gelatine containing a quantity of alkali sufficient to neutralize free acid present to the extent of 0·1 oz. per gallon of water. A small portion of lacmoid solution is then added, and if a pink color is obtained, it indicates the presence of more than 0·1 oz. per gallon of free acid; if a violet color is obtained, the solution contains less than 0·1 oz. of free acid per gallon.†

Treatment of Mixed Sulphide Ores.—This subject continues to receive the attention of many investigators, but save for the improvements in the methods of gravity and magnetic separation which have made it commercially profitable

* *Electrician* (London), Jan. 19, 1900. † *Engineering* (London) July 27, 1900.

to produce an inferior grade of zinc ore at Leadville, Colo., and Broken Hill, N. S. W., whence large quantities of such a product were exported in 1900, no practical progress has been made. The British Sulphides Smelting Co. is engaged in exploiting the Ellershausen process on rather a large scale in France and the Swinburne & Ashcroft electrolytic process for the decomposition of raw sulphide ore in a bath of zinc chloride has received some attention. On the other hand it is reported that the Hoepfner and Dieffenbach electrolytic processes have been abandoned at those places in Europe where they have been tried.

Guy de Bechi, of No. 17 Boulevard de la Madeleine, Paris, France, in connection with the General Metal Reduction Co., Ltd., of No. 85 Gracechurch Street, London, patented a process which consists in smelting mixed sulphide ore with from 30 to 60% of sodium chloride, a suitable flux varied according to the nature of the gangue being also added for the purpose of forming a proper slag. The mixture of ore, salt and flux together with a binding material if necessary is compressed into blocks of a size suitable for smelting in a cupola furnace. The air is blown into the furnace at different heights in such a manner that in the upper part of the shaft there will be an excess of air whereas in the lower part only such a quantity is supplied as is necessary to burn the fuel and smelt the ore. The smelting is performed at such a temperature that most of the zinc will be volatilized, under which conditions some of the lead and other metals will also be driven off. The fumes are collected in condensing towers or "some other suitable device and the metals are subsequently separated from the condensed fumes in any convenient manner." Matte is tapped off from the bottom of the furnace. A certain amount of the lead in the ore will go into the matte, but if the tenor of lead in the original ore does not exceed 10% most of it, according to the patentees, is volatilized together with the zinc. The use of sodium chloride in the charge is considered of great importance for the successful volatilization of the metals and the production of a good slag.*

De Bechi also patented a process for the treatment of mixed sulphide ores, which consists in roasting the ore in the presence of air and steam and conveying the vapors over sodium chloride in another furnace, whereby the following reaction is effected:

$$2NaCl+SO_2+O+H_2O=Na_2SO_4+2HCl.$$

The hydrochloric acid fumes obtained by the above reaction are condensed in suitable towers and employed for the lixiviation of the ore. Inasmuch as the ore will invariably contain soluble sulphates, a solution of calcium chloride which is obtained as a by-product in a subsequent stage of the process, is added to the hydrochloric acid solution, for the purpose of precipitating the sulphuric anhydride as calcium sulphate, while the metals previously existing as sulphates are taken into solution as chlorides. The metals thus brought into solution as chlorides are precipitated fractionally as hydroxides by successive additions of milk of lime (CaO,H_2O). No claim of discovery is made to any of these reactions, but only to their combination.

The patent specification contains some interesting data as to the properties of

* British Patent No. 17,057, Aug. 22, 1899.

zinc hydrate when precipitated by means of lime. The precipitate is found to contain insoluble zinc or lime oxychlorides or both, which it is practically impossible to eliminate by washing. By moderately heating the precipitate the combined water is driven off and an impure zinc oxide of low density is produced. Because of its lightness and the presence of the oxychlorides it is impracticable to reduce this oxide by distillation, since fumes are discharged from the retorts, which are not only very deleterious to the furnace men but also carry away a good deal of zinc. In order to refine the impure hydroxide and render it suitable for distillation De Bechi proposes to wash and dry it and then heat it to bright redness in a muffle furnace, whereby the oxychlorides are decomposed with the liberation of chlorine and the vapors of zinc and zinc compounds. The fumes are conducted to a condensing tower wherein the zinc is dissolved in a weak solution of hydrochloric acid, from which it is subsequently recovered "in any suitable manner." The fumes are found to carry off from 7 to 10% of the zinc contained in the hydrate. The residue remaining in the furnace which consists of nearly pure zinc oxide is mixed with the proper proportion of reducing agent and compressed into briquettes suitable for charging into the retorts of the distillation furnace. The residue from the original lixiviation is smelted in a blast furnace in the usual manner. It is proposed, however, to condense the fumes from the latter and unite them with the ore that is to be leached with hydrochloric acid.*

The Chemische Fabrik Marienhuette of Langelsheim in the Harz patented a process for the treatment of lead blast furnace slags containing zinc and barium. Such slags are produced in considerable quantity at the Juliushuette and Sophienhuette at and near Langelsheim. The slags are pulverized in ball mills and mixed with calcium chloride in the proper proportion are smelted in an oxidizing atmosphere in a reverberatory furnace at about 1,200°C. The product discharged from the furnace is pulverized again in ball mills, after cooling, and is then leached with warm water, yielding a concentrated and almost chemically pure solution of barium chloride and a residue consisting of calcium sulphate and zinc and iron subsilicates. The residue still damp is treated in lead pans with 50°B. sulphuric acid, whereby the black mass, evolving heat from the reaction which takes place, in a few minutes becomes soft and then sets. The product is mixed with calcium chloride and pulverized and is then introduced into a furnace where it is heated to about 500°C. with admission of air and frequent stirring, whereby zinc and iron chlorides are formed, of which only the ferrous chloride is decomposed at the temperature existing in the furnace. The decomposition of the ferrous chloride is represented by the following equation:

$$2FeCl_2+2H_2O+O=Fe_2O_3+4HCl.$$

The hydrochloric acid gas thus formed is conducted over lime or calcium carbonate for the regeneration of calcium chloride. The product discharged from the furnace is thrown still hot into water and leached, whereby there is obtained a concentrated solution of zinc chloride, nearly free from iron, and a residue consisting chiefly of calcium sulphate and ferric oxide, which after grinding and

* United States Patent No. 656,497, Aug. 21, 1900.

drying is marketable as a red pigment of considerable value, being in fact of substantially the same composition as commercial Venetian red.*

The Ellershausen process in its latest development was described in the *Engineering and Mining Journal* of August 11, 1900, on the basis of the reports of W. B. Middleton and W. Dewar. The ore is smelted raw in a cupola furnace. The whole of the lead, nearly all the zinc and 50% of the silver are volatilized as oxide, sulphide, sulphite and sulphate. The gases of combustion and the fume are drawn from the furnace by means of fans and are subjected to a system of wet condensation wherein the fume is churned up violently with the water. In that process most of the zinc goes into the solution as sulphate, while the lead and silver compounds together with the zinc existing as sulphide, being insoluble are subsequently separated in the form of a sludge. The sludge is filter-pressed and afterward dried on floors. When dry it is charged into a boiling hot solution of caustic soda contained in an iron pot. The lead content of the sludge is immediately reduced to metallic form, carrying the silver with it. The pot residues after cooling are broken up and passed to a leaching tank where the soda compounds are dissolved and the zinc sulphide is precipitated. The soda liquors are then run into the solution of zinc sulphate, precipitating the zinc as sulphide, hydrate and carbonate, the soda compounds being simultaneously converted to sulphate. The sodium sulphate solution is then evaporated and treated by the black-ash process for the reproduction of caustic soda for further use in the process. The matte which is tapped from the blast furnace collects the gold and copper of the ore and such silver as is not volatilized. This process has been tried experimentally on rather a large scale at Angoulême in France.

Dr. Karl Hoepfner, lately deceased, described an improvement upon a certain one of his processes patented previously. According to this latest patent the ore after roasting is treated with sulphurous anhydride (SO_2) or sulphurous acid (H_2SO_3) so as to form soluble zinc bisulphite ($H_2ZnS_2O_6$) in a solid or semi-solid form, but preferably in a solution which can be separated readily from the residue. The free sulphurous acid contained in the solution is neutralized or otherwise eliminated and zinc monosulphite is thereby precipitated. The zinc sulphite thus obtained is mixed with its equivalent of sodium chloride, together with some ferric oxide, which latter acts as a carrier or contact substance, and is then subjected to the action of warm air, whereby the following reaction takes place:

$$ZnSO_3+O+Fe_2O_3+2NaCl=Na_2SO_4+ZnCl_2+Fe_2O_3.$$

Otherwise zinc sulphite may be converted to sulphate by heating in the presence of air, and sodium chloride being added in excess, zinc chloride is obtained by double decomposition, the reactions being expressed as follows:

(1) $ZnSO_3+O+Fe_2O_3=ZnSO_4+Fe_2O_3$ and
(2) $ZnSO_4+Fe_2O_3+2NaCl=ZnCl_2+Na_2SO_4+Fe_2O_3$.

In either case zinc chloride is separated from the sodium sulphate, by treatment

* *Chemische Zeitung*, 1900, p. 503; *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, Jan. 12, 1901; German Patent No. 112.018.

with a quantity of water or sodium chloride solution, which is just sufficient to take up the zinc chloride without dissolving any considerable quantity of the sodium sulphate. The solution of zinc chloride is then subjected to electrolysis. The residue containing the sodium sulphate, together with some of the zinc chloride is dissolved by a fresh addition of water or sodium chloride solution and the sodium sulphate is recovered by crystallizing out by refrigeration, whereby any remaining zinc chloride is obviously recovered also. Dr. Hoepfner stated that the sulphurous anhydride obtained from the roasting could be used advantageously, while yet hot, for the treatment of the zinc bisulphite solution, heating the bisulphite and causing it to give up its free acid and precipitate the zinc as monosulphite and at the same time cooling and considerably enriching in sulphurous anhydride the gases which are to be used for extracting the zinc from a fresh lot of ore.*

Dr. Hoepfner also patented the following process for the production of zinc chloride from zinc carbonate, natural or artificial:† The zinc carbonate, obtained in the form of a natural calamine or artificially by carbonating zinc oxide with carbon dioxide is treated with a suitably concentrated solution of calcium chloride above normal temperature and under pressure, preferably in a closed vessel, whereby the following reaction is effected:

$$ZnCO_3+CaCl_2=ZnCl_2+CaCO_3.$$

The solution of zinc chloride thus obtained is decomposed electrolytically. Since it is not always practicable to decompose electrolytically all the zinc chloride in the solution thus obtained, a portion thereof or a portion partly freed from zinc electrolytically may be treated with milk of lime, whereby zinc hydroxide is obtained which may be electrolyzed by the process described in United States Patent No. 629,685, issued to Dr. Hoepfner July 25, 1899. Instead of calcium chloride potassium and magnesium chlorides may be used.

When the process is adapted to the treatment of sulphide ores, the latter are roasted to oxide and treated with a solution of calcium chloride and carbonic acid while being stirred.

The vessel in which these reactions are effected, is illustrated in the accompanying engraving (Fig. 6) which shows a cylindrical kettle *A*, with a steam or hot water jacket *a* and suitable openings *C* and *D* for the charging and discharging of the ore and solution. The stirring mechanism will be understood readily from the engraving. The lower end of the spindle rests on the step *f*, while the upper end passes through the stuffing box *g*. The valve *k* permits the escape of the air that may be forced in with the carbonic acid gas.

These two processes represented Dr. Hoepfner's latest ideas for the treatment of mixed zinc ores. In a letter dated September 3, 1900, he stated that the calcium chloride method was especially applicable at places where that substance is cheap, *e.g.*, in connection with ammonia soda works, but it has the drawback of leaving some zinc undissolved with the large residue of calcium carbonate. In other places he favored the sulphite process. In the case of ores too rich in lead

* United States Patent No. 663,759, Dec. 11, 1900. (Application filed Nov. 18, 1897.)
† United States Patent No. 664,269, Dec. 18, 1900. (Application filed Nov. 18, 1897.)

to permit of a good roasting he proposed to treat the raw ore by a method analogous to his well known cuprous chloride process for the production of copper. The sulphides of lead and silver, he said, were dissolved with surprising rapidity, the cupric chloride being converted into cuprous chloride, while zinc sulphide remains as an insoluble residue. Lead is easily recovered from the solution and

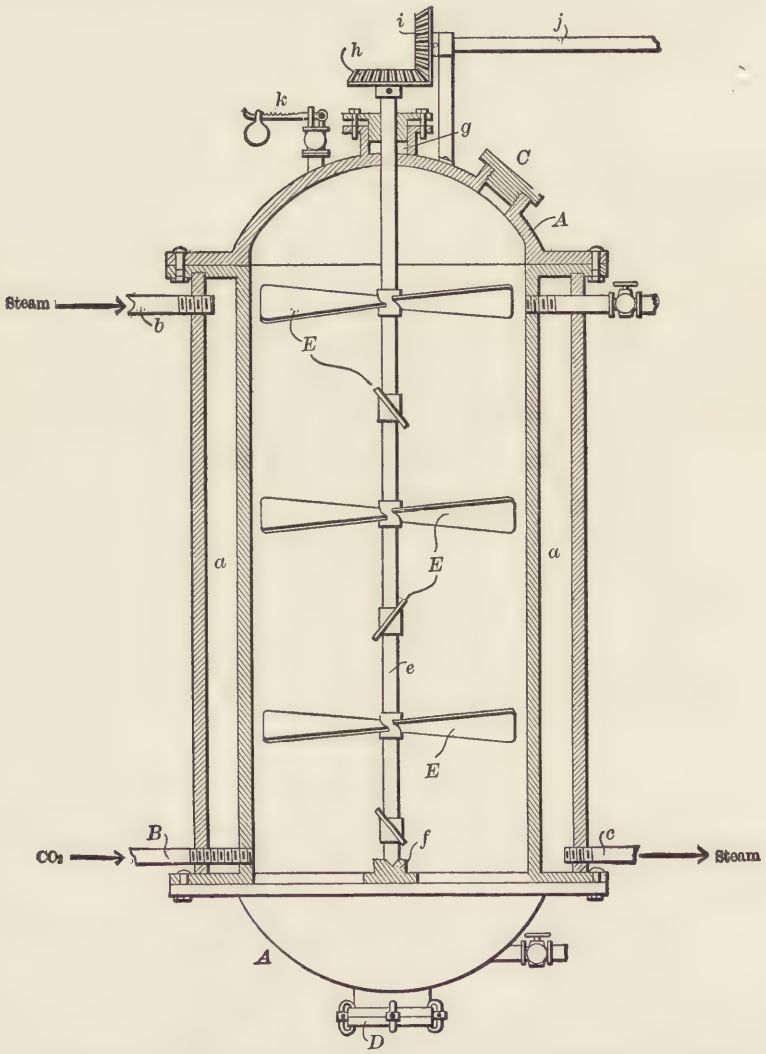


FIG. 6.—HOEPFNER'S KETTLE FOR CARBONATING AND LEACHING ZINC OXIDE.

the cuprous chloride is reconverted into cupric chloride and used for dissolving more lead. Owing to the rapidity of the reactions a very small plant would have a great capacity.

J. Rontschewsky described experiments upon the electrolysis of zinc solutions with the simultaneous recovery of valuable products at the anode. He employed anodes of lead and an electrolyte of zinc sulphate, to which a small percentage of

sodium chlorate was added. By a proper adjustment of the conditions he was able to obtain a solid deposit of zinc on the cathode and a product of lead peroxide, formed through the agency of the chloric acid set free at the anode. In decomposing a solution of zinc sulphate containing sodium chlorate the chloric acid anion combines with the lead which goes into solution as lead chlorate. The latter is converted into lead sulphate by the action of the sulphuric acid anion, and the lead sulphate is further oxidized by another portion of the sulphuric acid anion according to the following equation:

$$PbSO_4+SO_4+2H_2O=PbO_2+2H_2SO_4.$$

The formation of the peroxide does not take place directly on the anode plate, but in close proximity thereto, wherefore it cannot hang to the plate. Zinc and sodium hydroxide are formed at the cathode. The sodium hydroxide combines with the sulphuric acid which is set free in the bath and leads to an accumulation of sodium sulphate in the electrolyte, from which that salt must be separated from time to time; that operation is, however, easily managed.

The best results were obtained experimentally with a solution containing 7·5% $ZnSO_4$ and 0·75% $NaClO_3$, at a temperature of 15° C. and a current density of one ampere per square decimeter. The process was said to go very smoothly, without the least tendency toward the formation of spongy zinc. The zinc separated as a dense, silvery-white metal and the chloric acid appeared to influence favorably the separation. The paper descriptive of these experiments is too long to be abstracted satisfactorily in a few paragraphs and those who are interested in further details should refer to the original.*

S. Stepanov, of St. Petersburg, Russia, patented a process for the extraction of zinc by electrolysis, wherein parchment diaphragms are employed to separate the anode and cathode, and there is a double system for circulating the electrolyte, one passing it through the anode chamber and the other through the cathode chamber to a common vessel, and then into vats filled with calcined ore. To avoid arborescence, the corners and edges of the cathode plates are rounded.†

Wilhelm Strzoda, of Zalenze, Germany, described a process for electro-chemically converting zinc into a soluble compound in an alkaline bath and decomposing that compound in the same vat simultaneously, with the deposition of metallic zinc on the cathode. The anodes and cathodes of the electrolytic vat are arranged in a suitable framework, which rests upon rollers at the bottom of the vat, and can be lifted out of the vat by means of chains. In operation the vat is filled with a 10% solution of caustic soda, into which zinc carbonate is charged. The zinc of the latter goes into solution as sodium zincate. This solution is decomposed by the electric current according to the following equation:

$$ZnO,Na_2O=Zn+Na_2O+O.$$

The sodium oxide of course is dissolved as caustic soda in the excess of water and the electrolyte is thus regenerated. During the operation the solution becomes heated to about 40 to 60° C. The process is assisted by keeping the electro-

* *Zeitschrift für Elektrochemie*, July 12 and 19, 1900, Vol. VII., Nos. 2 and 3.

† British Patent No. 22,710, Nov. 14, 1899.

lyte in constant agitation, so that fresh ore is enabled to reach the cathodes. When the process is completed the anode and cathode plates are lifted out so that the spent residue may be removed from the vat.

James Swinburne and *Edgar A. Ashcroft,* both of Grosvenor Mansions, 82 Victoria Street, Westminster, London, patented* an improvement on their process previously described for the treatment of mixed sulphide ores by electrolysis of molten zinc chloride. In the improved process the ore is crushed and mixed with fused zinc chloride or fused zinc chloride with sodium or potassium chloride. The mixture is put into a suitable vessel like a copper converter, and chlorine gas is blown through it from the bottom. At low red heat it is claimed that the chlorine gas attacks the metallic sulphides and liberates their sulphur, the reaction being most vigorous at temperatures well above the fusion point of zinc chloride. Inasmuch as the reaction is exothermic, the temperature may be maintained and regulated by increasing or decreasing the blast of chlorine. If the temperature be raised to the volatilization point of the metallic chlorides, the entire contents of the vessel may be distilled off with the exception of the gangue of the ore.

The reaction having been started in the converter, fresh supplies of ore are added until the gangue accumulates to the extent that the mixture becomes too thick for working. Whatever iron is contained in the ore may be converted into the ferric state by chlorine and in that state it is readily precipitated as ferric oxide by the addition of zinc oxide in the form of roasted zinc ore. Manganese may be precipitated in a similar manner. Toward the end of the process an excess of chlorine may be necessary in order to insure oxidation of all the iron to the ferric state.

The sulphur set free by the chlorine is collected and condensed, being recovered in a comparatively pure form. Any chlorine that passes over at the completion of the working of a charge is returned to the chlorine store after condensation of the sulphur, care being taken to avoid the formation of sulphur chloride by keeping the chlorine from coming into contact with the sulphur. If metallic chlorides are distilled over and condensed with the sulphur, they may be recovered by fractional distillation or by leaching with water.

The charge remaining in the converter after the reaction has been completed, consists of metallic chlorides intermixed with the gangue of the ore and precipitated iron and manganese. This mixture is poured into a separate vessel or furnace and allowed to settle, after which the chlorides are drawn off as completely as possible. The chlorides are then treated with zinc to precipitate lead together with gold and silver, or the lead and subsequently the zinc may be precipitated by fractional electrolysis. If the lead be precipitated by zinc, the mixture of zinc chloride with sodium and potassium chloride is decomposed by electrolysis. In the converter it is preferable to have only zinc chloride but for electrolysis the double chlorides of zinc and sodium or zinc and potassium are preferred because they decompose but little on drying and are more fusible and conduct better; they also fume but little on melting and exposure to the air.

The zinc chloride remaining with the gangue after decantation is recovered

* British Patent No. 14,278, of 1899.

by distillation or by lixiviation with water. The chlorine from the electrolysis vat may be pumped directly to the converter, but preferably it is cooled and compressed and stored in the liquid state. The electrolysis is best carried on in a vat which is heated and kept hot by the electric current which causes the decomposition of the chloride; the pressure necessary at the terminals of the bath will depend to a large extent on the means employed to conserve the heat in the bath.

This interesting process, which is novel in so far as the direct recovery of sulphur is concerned, was criticised editorially in the *Engineering and Mining Journal* of November 17, 1900, on the ground of practical difficulties in handling the molten zinc chloride, in effecting the separation of the sulphur from volatile chlorides, and in recovering zinc chloride from the gangue when the accumulation of the latter has made the bath too thick for further use. It was pointed out that when zinc sulphide is heated in a stream of chlorine the reaction which takes place is the following:

$$2ZnS+6Cl=2ZnCl_2+S_2Cl_2.$$

There is no record in chemical literature of the decomposition of a metallic sulphide with the production of the corresponding chloride and sulphur, and if sulphur be obtained it is presumably from the dissociation of sulphur monochloride (S_2Cl_2) which is an unstable compound.

Mr. W. J. Huddle of the Indiana University was led by the criticisms of the *Engineering and Mining Journal* to make some experiments upon the reactions involved in the above described process, the results of which he communicated to the *Engineering and Mining Journal* of May 4, 1901. He found that in treating zinc sulphide with dry chlorine gas at temperatures varying between 150 and 300°C. up to 250°C., the monochloride of sulphur was formed with little or no sulphur. Above that temperature, however, as soon as a little of the sulphide had been decomposed, sulphur and not the monochloride was formed. Only a small portion of the ore was acted on by the chlorine in these experiments. The attempt was next made to duplicate the conditions of the patent. To that end dry gas was blown through the mixture of the ore and fused zinc chloride in a retort, care being taken that the apparatus be dry. Temperatures varied from 250°C. to red heat. In no case was the monochloride formed.

Zinc chloride melts at 250°C., so the negative results of the first experiments above that temperature, after a little zinc chloride is formed, together with the results of the second experiments point to the conclusion that sulphur monochloride is not formed from zinc sulphide in the presence of fused zinc chloride.

The action of the chlorine gas on the sulphide ore even when passed through a 100-mesh sieve is not at all vigorous. In an experiment conducted at low red heat about 4 g. of ore were used, only about two-thirds of which was acted upon by 25 g. of chlorine. At that temperature some of the zinc chloride distilled over, since that compound begins to distil at 400°C. At lower temperatures, the action is even more feeble. The separation of sulphur also offers difficulties. It cannot be done by distillation inasmuch as sulphur does not go over below 458°C.

Mr. Huddle concluded from his experiments that the process is impracticable in its essentials and will scarcely succeed.

PYRITIC SMELTING.

By Franklin R. Carpenter.

The term "pyritic smelting" is one that is badly abused, the two senses in which it is used referring to two widely separated processes. The term as introduced into English by Dr. John Percy meant a process of smelting in which pyritiferous material is utilized to form a regulus or carrier for the precious metals. By its means the gold and silver contained in a large number of tons of earthy gangue were concentrated into a few tons of matte. It had nothing to do ordinarily with the smelting of sulphide ores and the pyrite was not even relied upon to any great extent for flux. This is the first or older pyritic smelting, and has received its best exemplification in America at Deadwood, S. D. There is a newer pyritic smelting applicable to pyritiferous ores which seeks to do the smelting by means of the fuel value of the iron and sulphur, employing coke only to a limited extent. So far as I am aware, it has received its best exemplification at Mt. Lyell, Tasmania, under the management of Mr. Robert Sticht. Between these two extremes, lie all sorts of pyritic smelting. One of the most favorable is perhaps that of Nutting at the Bingham Copper and Gold Co.'s smelter, Utah. I am informed that the charge consists of cupriferous pyrites and siliceous ores, so constituted that the silica of the charge shall be 10% in excess of the metallic iron. To this charge is added 12% of lime and 12% of coke. The furnaces are three in number, each 40×176 in., and 9 ft. from tuyeres to feed floor. There are 16 tuyeres of 2·5 in. diameter upon each side. The slag and matte overflow from a side tap. Cold blast is employed. Each furnace has a capacity of about 150 tons per day, effecting a concentration of five into one.

John S. Loder operates a system of pyritic smelting at Leadville, and at Ouray, Colo. (Later: this plant was destroyed by fire March 30, after running for only six weeks.) By means of the Loder "hot-air" device, the air is passed through a coil of pipe in the top of the furnace, and is heated by the waste heat, the furnace being run with a very hot top. This hot air apparatus is similar to those used in the iron smelting 50 years ago for utilizing the waste heat from the top of the cupola. Loder's work has been quite successful, and is worthy of encouragement.

S. E. Bretherton practices pyritic smelting by means of the Bretherton hot-air attachment. The forehearth is enclosed in brickwork, over the top of which is a sheet-iron or steel box, rectangular in shape, having tubes passing through it, much the same as in a tubular boiler. The air blast passes through the box, and absorbs the heat from the forehearth through the tubes. Upon the top of the forehearth is burned wood, coal, or other fuel. It will be seen that it is in reality a hot-air strove. The device has been reviewed and most severely criticised

by H. Lang,* who claims that but little heat can be had from the forehearth proper, and that the advantage is derived from the wood burned upon its surface. For my part, however, I believe, that the forehearth forms a rather novel grate, and that a better separation is obtained with it as it keeps the slag fluid. The waste heat from the slag (if any) is, of course, utilized. Mr. Bretherton's work has been done mainly at Silver City, N. Mex., and descriptions of it have appeared from time to time in the *Engineering and Mining Journal.* His plant was sold to the American Smelting & Refining Co., which, I am informed, has rejected the hot air device after giving it a fair test.

E. W. Walters operated a pyritic smelter at Silverton, Colo. The ordinary "U" pipe stove was used, which for some reason, was built wrong end to, the air being blown into the hot part of the stove, and discharged from the cold end. The walls were very thin, and there was a great loss of heat by radiation. The stove proper consisted of 48 six-inch U pipes. The man who fired the boilers also fired the stove as well. The fuel used was half lump and half slack coal, costing at the plant $3·15 per ton. A volume of 8,450 cu. ft. of air per minute was heated to a temperature of 700° F., and the action easily maintained at a cost of 10 tons of fuel and the wages of one man, equaling in all $34·50 per day. The cost of hot blast per ton of ore smelted was 22c. per ton. The gain in tonnage by use of hot air was estimated at 36%. Mr. Walters reports great ease of smelting, thorough activity of the entire tuyere zone, uniformity of concentration, and avoidance of a climbing heat in the furnace. A temperature of the air blast of 700° F. could easily be maintained, but beyond this the cost rapidly increased. A comparison has been furnished of two runs on identically the same ore charge, with the same volume of pressure and blast. As figures relating to the use of hot air are rather hard to get, I quote his statement in full.

"This run represents about 72 hours with hot blast and 90 hours with cold, on identically the same charge with the same pressure and volume of blast. The air was at a temperature of 700° F. The physical character of the ore was rather fine. Charge refers to ore only.

	Hot Blast.	Cold Blast.
Coke per charge	150 lb.	300 lb.
Number of charges per 24 hours	150	104
Total coke consumption	22,500 lb. or 11·25 tons.	31,200 lb., or 15·06 tons.
Cost, @ $7 per ton	$78·75	$109·20

"It therefore costs $30·45 less for coke to smelt 150 tons ore with hot blast than to smelt 104 tons ore with cold.

Increase in number of charges per 24 hours when using hot blast, 150–104	46
Average approximate treatment, cost per charge	$4·00
Additional treatment at practically the same labor cost	$184·00
Saving in coke consumption (as above)	30·45
	$214·45
Less cost of operating stove	35·00
	$179·45
Less cost of additional lime flux	12·00
Difference in cost per 24 hours by using hot blast	$167·45

* *Engineering and Mining Journal*, May 26, 1900.

Hot air stoves heated by the waste heat from the furnace are fully illustrated in the old metallurgies of Phillips and Overman. The U-pipe stove is, of course, unpatented and broadly speaking, hot air, as an accessory to pyritic smelting has not been, and doubtless, cannot be patented.

Three papers, of more or less value, upon the subject of Pyritic Smelting, have appeared during the year 1900. I have described the older type of pyritic smelting as practiced at Deadwood.* The ores at Deadwood, upon which a smelting charge can be had, consist of an altered sandstone, carrying gold and silver. The former seldom exceeds an ounce, and the latter averages about two ounces per ton. The ores average 76% SiO_2, 12% FeO, the remainder being lime, magnesia and alumina. The flux used is a dolomitic limestone of great purity, and of the ordinary proportion of magnesia to lime. The pyritic material is absolutely barren of gold, silver and copper, and carries 30% SiO_2. Homestake concentrates running 25% SiO_2, carrying not over $8 in gold and silver values per ton, are also used. Copper ores are brought from Butte, a distance of about 700 miles. Owing to the keen competition for these ores at Butte, copper ores are handled at a loss in Deadwood. The local coke carries 24% ash. Coke from the East, of a better grade, is employed in quantities about equal to the local supply. It will be seen that the ore charge is not only very low in value, but extremely siliceous, and the conditions for smelting are as unfavorable as can be well imagined, yet the plant has been in operation 11 years, and with this very unfavorable charge, nearly 1,000 tons are daily smelted. This 1,000 tons of charge is concentrated into about 10 tons of matte, or 100 tons of charge into 1 ton of matte, a case without a parallel, I believe, in present or past metallurgical treatment. The slags made are no less remarkable than the degree of concentration obtained. They are given in the subjoined table:

ANALYSES OF DEADWOOD AND DELAWARE SLAGS.

Date.	SiO_2	FeO.	Al_2O_3.	CaO.	MgO.	Oxygen in Acid.	Oxygen in Base.	Silicate Degree.	
								RO.	SiO_2.
Usual Slags Made with Dolomitic Limestone.									
Jan. 4, 1898.....	50·6	16·3	2·3	18·3	11·9	1·84	1	1·09	2
Jan. 29, 1898.....	47·5	16·8	4·9	18·7	11·8	1·57	1	1·27	2
Feb. 17, 1898.....	45·7	17·6	6·1	17·9	10·1	1·53	1	1·31	2
Dec. 5, 1898.....	49·1	15·0	4·2	18·47	10·6	1·76	1	1·14	2
July 14, 1899.....	48·0	13·0	5·4	20·0	12·9	1·57	1	1·27	2
Sept. 9, 1895.....	49·0	11·11	5·86	22·6	12·04	1·58	1	1·26	2
April 23, 1896.....	47·5	9·64	7·00	22·6	9·10	1·63	1	1·23	2
Experimental Slags Made with Pure Limestone.									
July 24, 1894.....	51·6	19·50	5·83	17·1	3·2	2·08	1	0·96	2
July 31, 1894.....	48·1	26·91	9·10	11·4	1·9	1·79	1	1·11	2

For the purpose of comparison, the slags made at Mansfeld, in Saxony are presented in tabular form. In both cases it will be observed that metallic oxides are of but little importance, and that the main reliance for fluxing the silica is laid upon the earthy bases—lime, magnesia, alumina, etc. This is an exemplifica-

* A paper read before the American Institute of Mining Engineers, August, 1900.

tion of pyritic smelting in the sense in which Percy first employed the term: "It is a concentration by fire of ores which cannot be beneficiated by water concentra-

ANALYSES OF MANSFELD SLAGS.

	Cu.	SiO_2.	FeO.	Al_2O_3.	CaO.	MgO.	Oxygen in Acid.	Oxygen in Base.	Silicate Degree.	
									RO.	SiO_2.
1.....	0·6	50·0	8·7	15·6	20·3	4.4	1·59	1	1·25	2
2.....	0·3	47·6	4·7	14·8	18·4	6·7	1·65	1	1·21	2
3.....	0·25	53·8	4·4	4·4	33·1	1.70	2·18	1	0·92	2
.....	0·3	48·47	4·64	17·0	23·2	2·2	1·56	1	1·28	2
.....	0·3	46·4	2·77	16·52	21·51	0·85	1·66	1	1·20	2
.....	0·75	48·2	10·75	16·35	19·3	3·2	1·52	1	1·32	2
.....	0·2	48·4	5·89	18·17	19·5	8·02	1·38	1	1·43	2
.....	0·3	46·8	7·21	17·64	19·15	3·68	1·48	1	1·35	2
.....	0·3	57·4	7·47	7·83	23·4	0·87	2·47	1	0.81	2

NOTE.—At Mansfeld Al_2O_3 is figured as acid. I have here figured it as a base in order to compare these slags with mine.

tion," and if I were permitted to suggest a new definition, I think I should adopt this one. It will be seen in the Deadwood process the fuel value of the sulphur and iron is in no sense an essential point.

A second paper upon the subject is by Mr. S. E. Bretherton,* who defines pyritic smelting as "the utilization of sulphides as both flux and fuel; the metallic bases, excepting copper, uniting with the silica to form a slag, and the copper acting as a collecting agent to gather the precious metals into a copper matte, the sulphur uniting with the oxygen of the blast to generate heat, just as the carbon from the fuel does." (Mr. Bretherton has overlooked the fuel value of the iron.) He asks the following questions:

1. Can as high a percentage of the values, gold and silver be saved with copper as with lead?
2. Can the ore be smelted as cheaply as with lead?
3. Can as many tons of ore be put into one ton of shipping product as in lead smelting?
4. Can copper matte be sold as readily as lead bullion?
5. Can as refractory ore be smelted as in lead smelting?
6. Can as cheap a slag be made?
7. Will the ore require more preliminary crushing and roasting?
8. Will a plant of the same capacity cost more than if the ore is to be smelted in a lead furnace?
9. Is the matting process as suitable for as many different characters of ore?
10. Will the copper matting process cost less than smelting ore with lead?

Mr. Bretherton states that he has been in the lead smelting business 12 years, and in the copper smelting business for 5 years, in both cases as superintendent and metallurgist, and then proceeds to answer all of the questions affirmatively, among them stating: (1) no loss of gold, and only 1% of silver; (2) pyritic smelting costs less than half of lead smelting; (3) concentration is from 8 to 15 tons into one; (4) a pyritic smelting plant costs not more than one-third that of a lead smelting plant. The whole discussion of the question is from the view of the

* *Engineering and Mining Journal*, Dec. 29, 1900.

practical metallurgist. The mixtures which he describes as the safest are given as 3% and over Cu, 20 to 30% Fe, 8 to 13% CaO, not over 10% Zn and Al_2O_3, 30 to 36% SiO_2, and from 10 to 30% S. Mr. Bretherton is said to be very successful in his work, especially at his new plant at Silverton, Colo., and his method of pyritic smelting may be taken as a case midway between the Percy and the newer pyritic smelting.

The third paper upon this subject is that of C. C. Longridge,* who defines the object of pyritic smelting as "the smelting of raw uncalcined pyritic ores solely by the heat generated from the rapid oxidation of their calorific constituents." The process has not been successfully accomplished without the aid of heat from some extraneous source, and Mr. Longridge, therefore, modifies his definition: "A fusion process, in which, as far as possible, the pyritic or sulphuretted constituents of the ore are utilized as a fuel, and concomitantly, of course, as flux or slag forming material and as a carrier or collector of the metals for which the ore is smelted." He discusses the subject under several heads:

1. The calorific constituents of pyritic ores.
2. The thermal relations between sulphides and carbonaceous fuels.
3. Estimation of carbonaceous fuel required in pyritic smelting.
4. Ore charges suitable for pyritic smelting.
5. Influence of carbonaceous fuel in pyritic smelting.
6. The slag forming constituents of pyritic charges.
7. Ores suitable for pyritic smelting.
8. Action of the pyritic furnace.
9. Furnace charges.
10. Matte concentration.

The article is confessedly inspired by the paper on pyritic smelting presented by Wm. Laurence Austin,† and probably contains nothing not already stated by Mr. Austin, although the presentation is in most interesting form. The ores suitable for this process, he states, are iron pyrites, pyrrhotite, arsenopyrite, chalcopyrite, blende and galena. The main heat supplying constituents being sulphur and iron which are only combustible in that state at which they exist at the moment of dissociation. This dissociation is effected by heating the compound to the necessary temperature, when iron and oxygen combine to form ferrous oxide, and the sulphur and oxygen to form sulphur dioxide, both reactions being accompanied by the evolution of heat. It is the object of pyritic smelting to utilize this heat. Mr. Longridge states that the exact estimation of calorific or fuel value of iron pyrites does not seem to have been determined by experiment, although the chemical changes that take place are not only very simple, but perfectly understood. Theoretically, the amount of "caloric" produced by decomposition and recombination of the constituents may be readily calculated, since iron pyrites consists roughly of 53% S and 47% Fe, and we have, after the expulsion of one equivalent of sulphur—in 100 lb. pyrites 47 lb. Fe and 26·5 lb. S, or, 73·5 lb. FeS. This burnt to ferrous oxide will evolve 2,284 B. T. U. A pound of ferrous oxide will yield 3,107 B. T. U. On the other hand, the combustion of carbonaceous fuel in the blast furnace is estimated at 5,600 B. T. U. The

* *Engineering*, June 15, 1900. † *Transactions of the Federated Institution of Mining Engineers*, Dec., 1897.

fuel value of 1 lb. FeS_2 is estimated at 40% of that of 1 lb. coke, and 1 lb. FeS at 55% of that of 1 lb. coke. From this Mr. Longridge proceeds to determine how much coke may be replaced by iron pyrites. If, in ordinary copper smelting, the fuel is 16·66% of the ore; 16·66% divided by 0·40 equals 46·6% pyrites; that is, a charge containing 46·6% pyrites, exclusive of the amount necessary to form matte, will generate heat enough to smelt the charge without coke or other fuel. The best slag for this process, he states, is the monosilicate one. Then follows a discussion of the action of a pyritic furnace, and the evils of blowing in more air than is necessary for combustion. His most remarkable conclusion is the following, which may be true theoretically, but is certainly not so in practice:

"The cooling produced by increasing the volume of blast is illustrated by Wm. Laurence Austin by the following formula, giving the maximum efficiency of any fuel burned in a blast furnace with a blast heated to 400°C.

$$Pn=\frac{Eag+0\cdot2375tq}{Epc—cn}=T.$$

P n is	maximum temperature attainable before the tuyeres.
a	calorific power of each element.
g	weight in pounds of each element.
t	temperature of blast in centigrade degrees.
q	quantity of air.
p	weight of each product of combustion.
c	specific heat of each product of combustion.
c n	specific heat of fuel.
0·2375	specific heat of air.

Then, in the case of iron monosulphide, when only the theoretical amount of oxygen necessary for the operation is introduced,

$$T=\frac{1155+0\cdot237\times400\times2\cdot3523}{0\cdot6683—0\cdot1357}=2587°C.$$

If the amount of air be doubled:

$$T=\frac{1155+0\cdot237\times400\times4\cdot7046}{1\cdot2258—0\cdot1357}=1469°C.$$

NOTE:—Solving this last gives 1478° actually—possibly the author made a slight error.

which is scarcely a smelting temperature."

Mr. Longridge's presentation of the subject is probably as able a one as has appeared—at least, in a newspaper article.

Some years ago Herbert Lang's book on "Matte Smelting,"* appeared, which was so far ahead of the times that it is only now beginning to be appreciated. All such points as the quantity of blast required, the size of the tuyeres, the rate of concentration, and the action of various compounds in the furnace, are most ably discussed, and, as the book has not been noticed in previous volumes of THE MINERAL INDUSTRY, this reference may not be out of place. In it, so far as I know, the first comparison of the different works and methods was made, and to it we owe many new terms now coming into general use.

* *Matte Smelting*, by Herbert Lang, 1895.

The wide difference existing in the practice at different plants, and the little we know may be illustrated by the following comparison: At Mansfeld, for instance, where slags similar to those at Deadwood, are made, we find the furnaces have a height of 25 ft. above the tuyeres, and the newer ones but four tuyeres, each 2·5 in. in diameter, giving what Lang has called a "tuyere ratio" of 1·5. At Deadwood, the furnaces are 15 ft. above the tuyere openings, but each furnace has 24 tuyeres 4·5 in. in diameter, or a tuyere ratio exceeding 10. An ordinary lead furnace has a tuyere ratio of about 3·5. At Mansfeld the number of tons per square feet of hearth area, with hot blast, scarcely exceeds the number of tons per square feet of hearth area at Deadwood, with cold blast, and yet see how widely different are the two methods of procedure.

The latest pyritic smelting is at the plant at Florence, Colo., designed by me. It consists of two furnaces, 3×15 ft. in cross section at the tuyeres, and each with 30 tuyeres. Each furnace is served by a separate blower capable of delivering 280 cu. ft. of air (cold blast) per square feet of hearth area per minute. The principal ores to be smelted consist almost wholly of earthy bases and silica—in fact, they are either granitic or phonolitic. They average 20% Al_2O_3, and have been the bane of the lead smelters. At present they are smelting them at Florence with dolomitic limestone, and sufficient copper and iron sulphide ores to form a matte. Apparently the slags made at Mansfeld would be ideal for these ores, but they failed absolutely. The greatest difficulty was experienced in getting a slag which would flow from the furnace when melted, and the expense of working out the problem has been very great. I cannot say more than that at this time complete success is promised, but by a method of pyritic smelting that is different in many details from any yet described.

In conclusion I wish to say that a term so badly abused as "pyritic smelting" deserves to be rejected entirely, or defined by competent authority so that we may know exactly what is meant by it. At Deadwood it means the smelting of siliceous ores by the help of iron pyrite. With Austin it means the smelting of pyrite ores by means of their calorific constituents. By the great majority of pyritic smelters it means the collecting of gold and silver in a matte. The first is the old Percy definition; the second is Hollway's process for bessemerizing iron pyrites; and the intermediate processes are those of ordinary matte smelting.

THE PROGRESS OF METALLOGRAPHY IN 1900.

By Albert Sauveur.

Metallographic methods of investigating the properties and treatment of metals have proved very fruitful during 1900, and the year's progress has been concisely outlined in the following summary:

I. Preparation of Samples of Metals for Microscopical Examination.—*Polishing.*—In order to examine the structure of metals through the microscope, it is necessary to polish a surface of the fragment until it is almost absolutely free from the minutest scratches. To accomplish this, it is quite evident that the sample must be rubbed successively over various abrasive substances of increasing fineness. Supposing the surface to be examined has been filed with a smooth file, the tool marks would not be removed and a perfectly specular condition could not be imparted to the surface in a single operation. The transformation must be gradual. The file marks must be effaced by rubbing the sample over a properly selected polishing substance, and replaced by finer markings. These, in turn, must be removed by a second rubbing with a finer abrasive agent, being replaced by still finer marks, and so on, until finally, the last operation removes the very minute marks from the previous treatment and leaves the surface absolutely free from scratches or nearly so. Emery powder of various degrees of fineness is the abrasive substance which naturally suggests itself, at least for the first treatments. The powders may be used in the shape of emery wheels, emery cloths or papers, or even spread loose over a suitable support, in which case it is kept wet during the rubbing. Emery may, of course, be replaced by carborundum for these operations. The polishing powder known as jeweler's or gold rouge suggests itself for the final polishing. It is generally spread over a piece of wash leather or other soft and smooth texture, which in turn is fastened to a block of wood. The powder is generally kept wet during the rubbing. The details of the manipulation vary greatly with different operators, but it may be said that they all use emery (or carborundum) in some form for the rough polishing and jeweler's rouge for the final treatment.

The markings left even by the finest emery powder, however (French emery paper, No. 000 and No. 0000), cannot always be removed readily by the rouge and the operation is frequently a long and tedious one. The need of a suitable

polishing powder to be used after the last emery treatment and before the final rouge polishing was soon made evident and many substances, such as water of Ayr stone, crocus, tripoli, diamontine, "brillant Belge," etc., have been tried. It is in this particular that the polishing methods of the various experimenters engaged in metallographic work vary the most. Somewhat roughly stated, the method at present in use for the preparation of metallic samples, is in most cases as follows:

Three treatments with emery (or carborundum) of increasing fineness.
One treatment with one of the powders mentioned above.
One treatment with jeweler's rouge.

It was also found that the emery powders and emery papers on the market are seldom of sufficient uniformity. They frequently contain some coarse particles which will scratch the specimens deeply and greatly lengthen the polishing operation. This fact led some experimenters to prepare their own emery powders and papers. Commercial emery powder is allowed to settle slowly through a column of water and is divided into several grades, according to the time required for settling. The resulting powders are more uniform and by their use the polishing operation is shortened and better surfaces are obtained. Emery papers can readily be prepared with these various grades of powder. The same treatment is sometimes applied to commercial jeweler's rouge.

The polishing may be done entirely by hand or it may be hastened by the use of some simple power-driven machine consisting of revolving emery wheels and discs upon which the various powders are spread. Until quite recently, however, and even with all the refinements outlined above, the number of treatments was seldom less than five, and the average time required for the preparation of a surface measuring 0·25 sq. in., was not far from 30 minutes when polished by hand and 20 minutes when a polishing machine was used. Occasionally a sample was prepared in a much shorter time, but others would require considerably more time, and the average figures just given, represented very good practice. The polishing of a larger surface will generally demand a correspondingly longer time.

It was, of course, very desirable to reduce both the time and the labor required for the preparation of the samples, and it is with that end in view that Prof. H. Le Chatelier* conducted some very valuable and fruitful experiments, of which the following is a brief description:

The levigation method of preparing polishing powders, as usually carried on, does not yield perfectly homogeneous products. The pulverulent matters in suspension in water contain some salts, especially of calcium, which have a tendency to cause the formation of lumps containing both coarse and fine grains. A very small amount of salt is sufficient to produce this result, the carbonate of lime present in ordinary water being more than sufficient. These considerations led to the adoption of Schloesing's method for the analysis of kaolins to the preparations of the polishing powders. The method consists in adding one part of nitric acid to every one thousand parts of water used in the operation, in order to dissolve the calcium carbonate and sulphate as

* *The Metallographist*, January, 1901.

well as other salts which might be present. After a few hours, and occasional stirring, the mixture is allowed to settle. The powder falls rapidly to the bottom, and the clear liquid above it can be easily decanted. This liquid is now replaced by distilled water, and the mixture stirred; it is again allowed to settle, and is then decanted. After a few similar operations, when all the acid has been removed, the settling takes place more slowly, and the liquid remains milky. The conditions are now favorable to proceed with the levigation, and the operation is further facilitated by adding 2 c.c. of ammonia to each liter of water, as it helps the suspension of the finest particles. Decantation is now resorted to, at stated intervals, by means of a siphon forming a hook at its extremity, so as to avoid disturbing the portions which have settled. The decantations are made at the following intervals: 15 minutes, one hour, four hours, 20 hours, eight days. The deposit left after the first decantation contains all the coarse grains unsuitable for polishing. The second deposit, resulting from the first decantation, after one hour's settling, yields a substance which is not yet very homogeneous, but which may serve to start the polishing. The third deposit constitutes a good polishing powder for hard metals such as iron. It is, however, the deposit collected between the first and the eighth day which constitutes true polishing powder. Instead of waiting eight days for the formation of the last deposit, it may be precipitated immediately after the removal of the 24 hours' powder, by adding some acetic acid, in order to saturate the ammonia. The totality of the powder, still remaining suspended, is then deposited after a few hours.

To preserve the powders thus prepared and prevent all possibility of their being contaminated by dust or other foreign matter, they are mixed with some shavings of castile soap, and sufficient water to make a thick paste when heated, which is preserved in tin tubes similar to those used for oil paints, paste, etc.

This levigation method has been applied to a number of substances, such as alumina produced by the calcination of ammoniacal alum; commercial emery powder; chromium oxide obtained by the combustion of ammonium bichromate; and iron oxide resulting from the calcination in air of iron oxalate. The alumina yielded by far the best results.

Prof. Le Chatelier uses now the following method for polishing samples of iron and steel, after they have been previously rubbed upon commercial emery papers, including the finest grades:

1. An emery paper prepared with albumine, according to Osmond, with the deposit obtained in between a quarter of an hour and one hour in the ammoniacal washing of flour-emery.

2. A felt disc, covered with some soap paste prepared with the deposit of alumina or of emery, obtained in between one and three hours.

3. A flat disc made of wood, metal or ebonite, covered with cloth, velvet or leather which is strongly glued upon it. Upon this covering the soap preparation, obtained with the deposit of alumina after 24 hours, is spread.

The last two discs are rotated by some mechanical device producing a great speed.

Under these conditions the polishing proper may be finished in about five

minutes. To this must be added the time required for preliminary treatment with commercial emery.

Mr. J. E. Stead* describes the polishing machine which he has finally adopted after much experimenting. It will be found illustrated in Fig. 1. Conical blocks are used for carrying the different polishers; they are dropped into the recessed wheel and carried round by friction. The outfit includes a can for holding water and a tap for allowing it to drop on the center of the polishing blocks.

After much experimenting, I have devised an arrangement by which the whole polishing operation is greatly shortened and simplified. My outfit

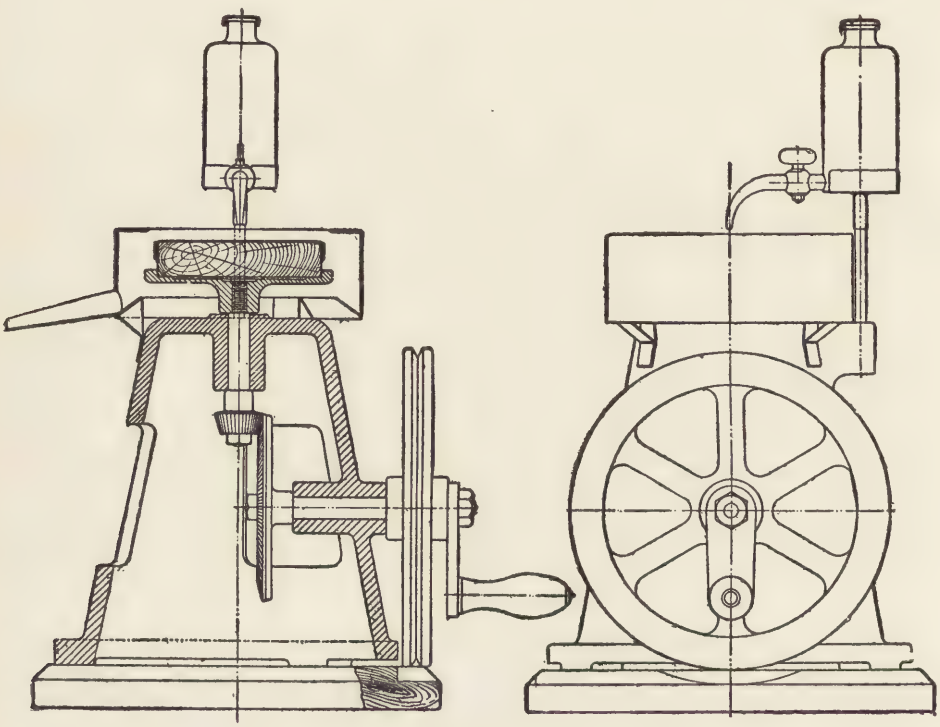


FIG. 1.—STEAD'S POLISHING MACHINE.

consists of a grinding machine of the usual style, carrying four discs revolving in a vertical plane and covered with suitable cloths—a simple arrangement permits the quick removal of torn cloths whenever necessary. In this way four polishing surfaces are obtained always ready for use with the additional advantage that they may be used simultaneously. This is decidedly better than Mr. Stead's arrangement in which one block only can be made to rotate, necessitating a frequent handling of the blocks and a greater consumption of time and labor. The four polishing surfaces of my outfit are fed automatically and simply. Water is fed near the center but the rapid revolution of the discs causes it to be immediately distributed over the entire surface. Shields

*A paper read before the Cleveland Institution of Engineers, Feb. 26, 1900; *The Metallographist*, July, 1900, p. 220.

are provided for catching the water thrown off the discs when at work. By properly regulating the feeding, the proportion of water, etc., the discs are at all times in perfect condition and require but little attention. A paste made essentially of tripoli and castile soap has been found very effective. With most samples the rouge polishing may be omitted, the entire polishing operation consisting of three treatments. Indeed, with some samples, two treatments suffice in which cases the operation lasts but three or four minutes. With the above outfit 5 or 6 minutes is a high average for polishing a surface measuring 0·25 sq. in. Two specimens may readily be prepared at the same time by one operator holding one sample in each hand and pressing them upon the two sides of the same disc. If the samples be delivered to him after filing them with a smooth file, one operator might readily prepare 15 samples per hour and probably more. The industrial importance of being able to prepare daily a large number of samples for microscopical examination will not escape the reader. At the rate mentioned above one operator could polish in one day's work a section from each blow of a three-vessel Bessemer plant, making an average of 150 blows per 24 hours.

II. DEVELOPMENT OF THE STRUCTURE.—*Iron and Steel.*—Many treatments have been tried to develop the structure of polished samples of iron and steel, *i.e.*, to make their structure apparent when examined under the microscope. To do this, it is necessary to impart unlike appearances to the various constituents. Of all the methods tried, it may be said that five only have been retained:

1. Etching with nitric acid (both concentrated and diluted).
2. Etching with iodine tincture.
3. Combined polishing and etching with a solution of ammonium nitrate.
4. Polishing in relief.
5. Heat tinting.

The proper way of conducting these various operations has been described on many occasions; I shall only indicate here the improvements which have been introduced during the past year in their *modus operandi.*

Prof. H. Le Chatelier* recommends applying the iodine tincture to the polished section with the tip of the finger, with constant rubbing; the etching is then more uniform, the constituents which are not acted upon remain brilliant, and the filling up of the minute parts, such as pearlite, by some deposit from the etching of other parts, is prevented. Fig. 2 shows the structure of a sample of gray pig iron etched by him in this way. The combined polishing and etching with ammonium nitrate proposed by Messrs. Osmond and Cartaud was described in my last review (THE MINERAL INDUSTRY, Vol. VIII., p. 762).

With regard to heat tinting, Mr. Stead† has applied this method extensively and with much success to samples of pig iron. He has found it especially effective, as will be seen in the following pages, in distinguishing between the pearlite areas and those of the phosphide eutectic soon to be described. His beautiful photographs, of which a few will be found reproduced in this article, testify to the excellency of the method for this special purpose. The following is his own description:

* *Loc. cit.* † *The Metallographist*, October, 1900, p. 261; *Journal of the Iron and Steel Institute*, No. II. 190.0.

"The best way of treating a specimen to enable one to identify these constituents is to heat the polished metal upon a hot plate till it assumes a purple tint to the naked eye. The various constituents oxidize at different rates, and assume correspondingly colored films. Heated in this way pearlite assumes a blue tint with brown red worm-like layers of carbide of iron. The massive carbide takes a fine red brown tint, the phosphide of iron a pale yellow color. The sulphides do not apparently change color, but are easily detected, as they appear of a slate color and exist in isolated segregations, very often in idiomorphic crystals.

"These colors only appear in this order if the heating has been correctly done. By longer heating the colors advance in sequentially progressive steps forward through yellow, brown, orange, red, purple, blue, to slate gray. Such specimens properly heat tinted are magnificent microscopic objects.

"The ordinary methods of etching do not enable one to find any difference between carbides and phosphides, and in the past some metallographists, myself included, have mistaken the one for the other.

"The heat tinting process enabled them to detect with certainty the phosphides."

He prepared the following table which indicates the colors assumed successively by the various constituents as the temperature rises from 200 to 400°C.:

HEAT TINTS OBTAINED WITH TEMPERATURES STEADILY RISING FROM 200 TO 400°C.

Pearlite. (0·6% P; 0·75% C.)	Iron.	Iron Carbide.	Iron Phosphide.	Manganese Sulphide.
White.	White.	White.	White, tinted yellow.	Pale lavender.
Very pale yellow.	White.	White.	White, tinted yellow.	Pale lavender.
Very pale yellow.	White.	White.	White, tinted yellow.	Pale lavender.
Yellow.	Very pale yellow.	White.	White, tinted yellow.	Pale lavender.
Yellow.	Very pale yellow.	White.	White, tinted yellow.	Pale lavender.
Yellow brown.	Yellow.	Very pale yellow.	White, tinted yellow.	Pale lavender.
Yellow brown.	Yellow.	Very pale yellow.	White, tinted yellow.	Pale lavender.
Brown.	Yellow brown.	Very pale yellow.	White, tinted yellow.	Pale lavender.
Brown.	Yellow brown.	Very pale yellow.	White, tinted yellow.	Pale lavender.
Red purple.	Brown.	Yellow.	Very pale yellow.	Pale yellow.
Purple.	Red purple	Yellow brown.	Very pale yellow.	Pale yellow.
Blue.	Purple.	Yellow brown.	Pale yellow.	Pale yellow.
Blue.	Blue.	Brown.	Yellow.	Pale yellow.
Pale blue.	Blue.	Brown.	Salmon.	Pale yellow.
Pale blue.	Pale blue.	Red brown.	Heliotrope	Brownish white.
Pale blue.	Pale blue.	Red purple.	Greenish.	Brownish white.
Pale pea-green.	Pale blue.	Purple.	Yellow.	Brownish white.
Pale pea-green.	Pale pea-green.	Blue.	Yellow.	Brownish white.
Pale yellow.	Pale yellow.			
White.	White.			

Mr. Stead finds that better results still are obtained by heating the samples to a certain constant temperature. This can be conveniently done by immersing them in a bath of metallic tin of a constant temperature.

The method which should be used for the development of the structure depends upon the nature of the metal, the treatment it has received and to a great extent, upon the characteristics of the structure which it is desired especially to reveal. It is not possible to state positively what developing method should be used in every case, so as to obtain the best resolution of the structure. No sharp lines of demarkation can be drawn in the application of the various methods.

Soft Alloys.—It is well known that the polishing of soft alloys presents much difficulty. For instance, in polishing an alloy of tin and lead, the lead spreads itself upon the tin in such a way that it is impossible to distinguish clearly

the structure under the microscope. In order to obtain smooth surfaces, Messrs. Irving and Rosenhain* proposed to cast such alloys upon plates of glass or of polished steel. In THE MINERAL INDUSTRY, Vol. VIII., I gave a few reproductions of the beautiful preparations obtained by them in this way. The frequent breaking of the glass plates was the most serious objection to the method, and this induced Mr. H. J. Hanover† to replace the glass plates by plates of mica, which gave very satisfactory results. Fig. 3 shows the structure of an alloy of lead and antimony (80% Pb and 20% Sb) prepared in this way. A background made up of a eutectic alloy, may easily be distinguished as well as large crystals corresponding to an excess of antimony.

Microscopical Outfit.—Prof. H. Le Chatelier‡ has devised a special microscope for the examination of metals and opaque objects in general. His instrument is illustrated in Figs. 4 and 5. *A* is the metal being examined, *B*, the support, *C*, fine adjustment for focusing the objective, *D*, objective, *E*, totally reflecting prism, *F*, eye-piece, *G*, a movable tube carrying the prism, *H*, tube carrying the eye-piece, *I*, projection eye-piece for photography, *J*, illuminating prism, *K*, Iris diaphragm, *L*, condensing lens, *M*, diaphragm, *N*, source of light, *O*, lens, *P*, absorbing cells, *Q*, photographic plate.

The superiority of this arrangement is not apparent. "Its greatest advantage," says Prof. Le Chatelier, "is found in the fact that it is only necessary to have one flat surface in the samples examined, which is placed upon the support taking the place of the stage of the microscope. The necessary adjustment to bring the polished surface in a plane perpendicular to the axis of the microscope is done away with, or the still more tedious operation of cutting two parallel surfaces on each specimen may be omitted. In either case a notable saving of time is gained."

Exactly the same advantages, however, belong to the special stand and specimen holder universally used in the United States, as illustrated in Fig. 6. With this outfit the metallic samples with only one flat surface and however irregular in shape, can be quickly placed upon the stage in the proper position. Several European writers apparently ignore the existence of this very simple contrivance, for they continue to describe elaborate and ingenious methods for mounting the samples or for cutting two parallel sides. With this outfit, as with that of Prof. Le Chatelier, it is only necessary to place once for all the source of light,—condensing lenses, etc.—in the proper position, the microscope being provided with a movable stage by means of which the coarse adjustment is done. In this way the vertical illuminator attached to the tube of the microscope always remains practically in the same position and the illuminating outfit never needs to be readjusted.

It is even doubtful whether Prof. Le Chatelier's equipment is more convenient for the examination of large pieces of metal, for there is little difficulty in properly supporting large sections for examination by means of the stand illustrated in Fig. 6. Indeed, the stage may be removed altogether and the stand placed

* *Philosophical Transactions of the Royal Society of London*, Vol. CXCIII., p. 353; *The Metallographist*, 1900, p. 94.

† *Bulletin de la Société d'Encouragement*, August, 1900; *The Metallographist*, 1900, p. 29.

‡ *The Metallographist*, 1900, p. 1.

upon the piece of metal to be examined, in which case there need be no limit to its size. On the other hand, it would seem as if his arrangement will not yield as intense an illumination, *i.e.*, a smaller proportion of the light emitted by the source of light will reach the eye, owing to the greater number of reflections to which the beam of light is subjected on its travel from the source to the eye, since, of course, every reflection is accompanied by some loss. Finally



FIG. 6.—MICROSCOPE WITH SPECIAL STAND AND SPECIMEN HOLDER.

Prof. Le Chatelier's stand cannot be applied to the examination of transparent objects by transmitted light and even such a specialist as a metal microscopist may sometimes desire to examine transparent slides.

For taking photomicrographs with Prof. Le Chatelier's outfit, the sensitive plate is placed at *I* (Fig. 5) and the totally reflecting prism, which is fastened to a draw tube, is withdrawn in order to allow the image of the object to form upon the sensitive plate. The resulting image measures only 15 mm. in

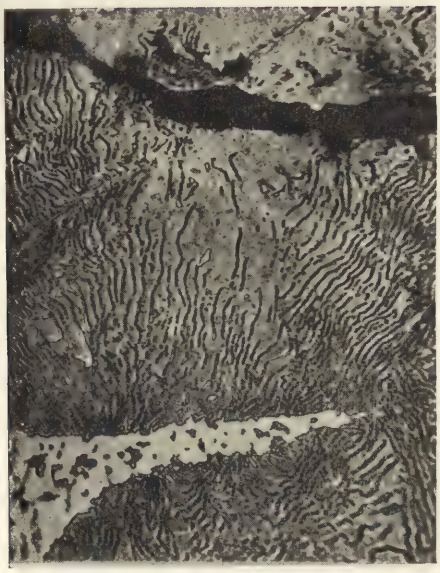


Fig. 2. Gray Cast Iron of good quality, etched with tincture of iodine. Magnified 660 diameters.

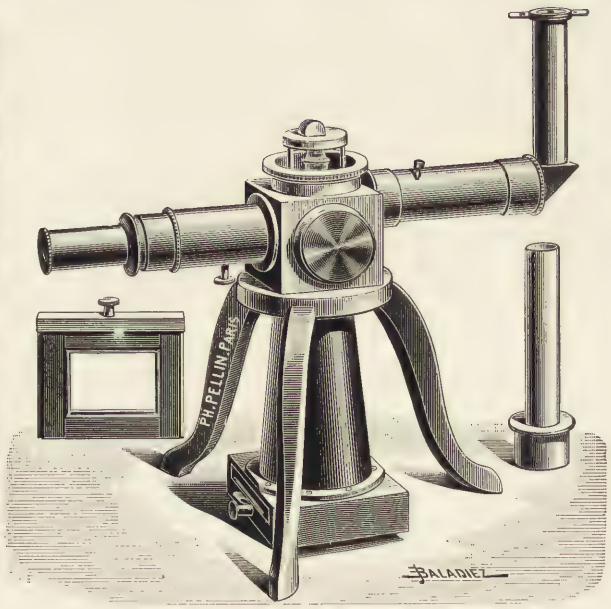


Fig. 4. Le Chatelier's Microscope.

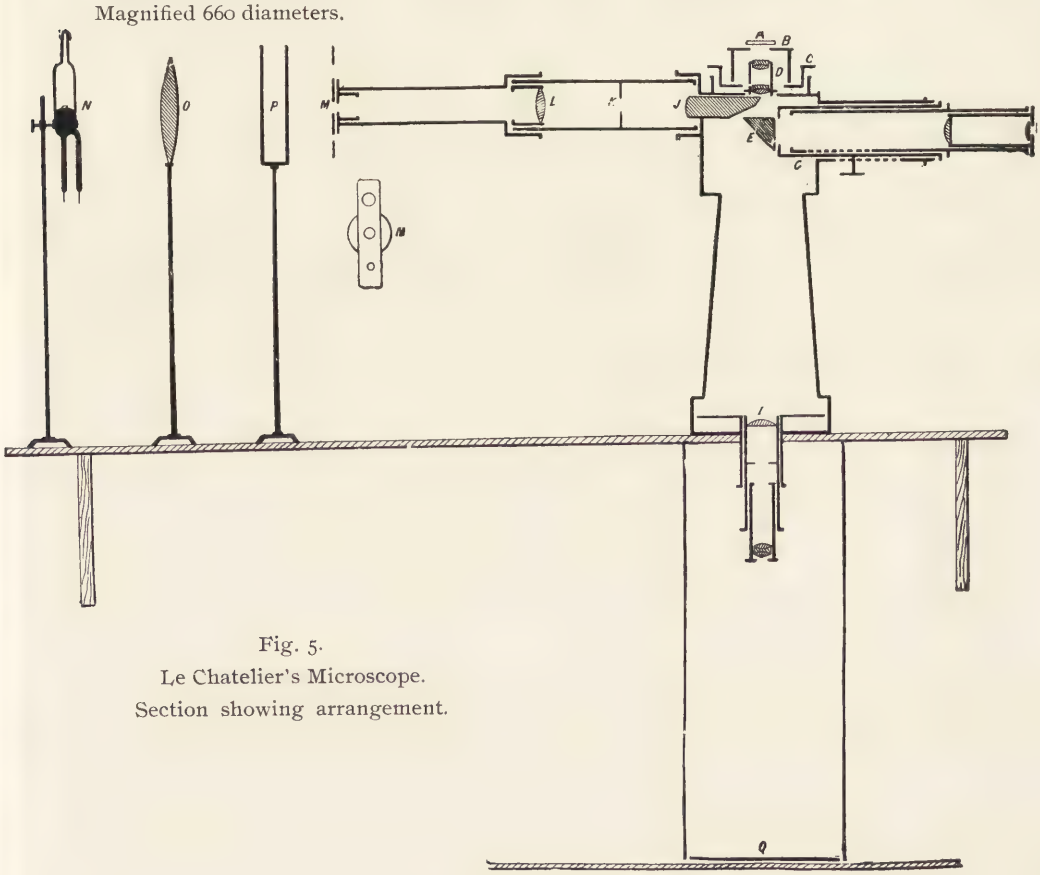


Fig. 5.
Le Chatelier's Microscope.
Section showing arrangement.



Fig. 3. Lead-antimony alloy—lead, 80 per cent.; antimony, 20 per cent.—cast on mica.

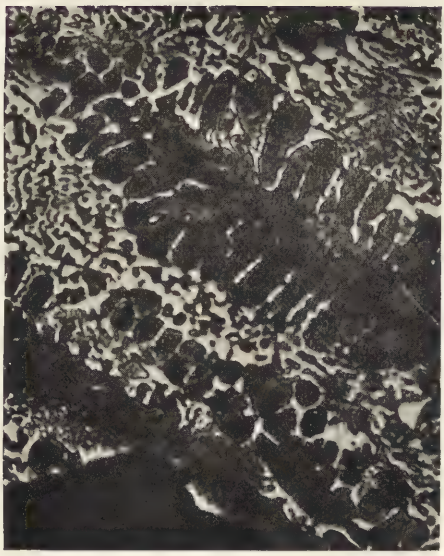


Fig. 8. Aluminum and eutectic alloy of Al and Al_2Cu.
Magnified 150 diameters.

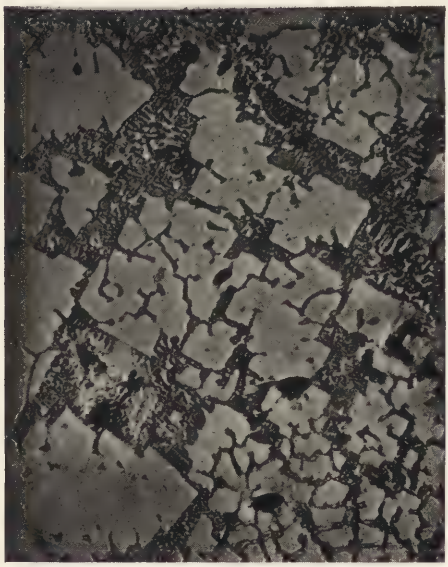


Fig. 9. Crystals of Al_2Cu.
Magnified 150 diameters.

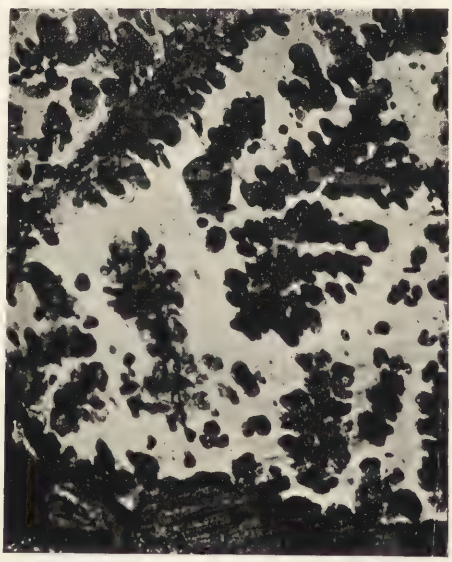


Fig. 10. Same as Fig. 11, etched with caustic potash.
Magnified 150 diameters.

diameter and must be subsequently enlarged to, say, 45 mm. With the use of a projective eye-piece placed at *I*, and by placing the photographic plate, say, 1 m. below, at *A* (Fig. 5), a much larger image may be obtained. It will be seen that with this arrangement the image cannot be focused upon a screen occupying the same position as the plate, as is usually done in photography. In order to have a properly focused image upon the photographic plate, the following manipulations described by Prof. Le Chatelier, are required: "The distance is such that when the image formed thereon by the objective is sharp, it is equally sharp for a mean position of the eye-piece, when viewed by the eye. This distance is determined tentatively by taking a series of photographs after focusing with the eye-piece in different positions. The latter is carried by a graduated tube, and its positions may therefore be recorded."

One will naturally wonder whether this indirect focusing method is not somewhat uncertain; whether it will yield very sharp images with high power objectives requiring such delicate focusing. These fears are somewhat lessened by the very good photographs taken with his outfit, a few of which are reproduced in Figs. 2, 8, 9, 10 and 11 of this article.

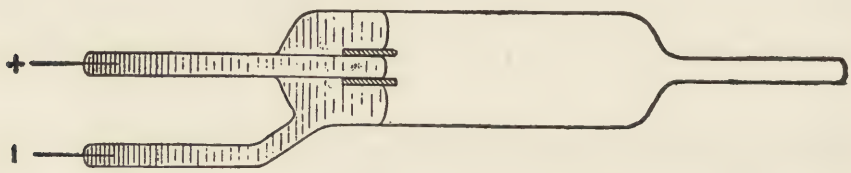


FIG. 7.—MERCURY ARC LAMP IN VACUUM FOR MONOCHROMATIC LIGHT.

Seeing that so-called achromatic and apochromatic objectives are never absolutely free from chromatic aberration, Prof. Le Chatelier recommends the use of a monochromatic source of light, especially for photography. He finds that an excellent monochromatic light is obtained by means of a mercury arc lamp in vacuum. In the lamp he uses (Fig. 7), the vacuum space is very large, so as to increase the radiating surface, and thereby decrease the heating of the lamp. The central tube is covered with a refractory coating which greatly lengthens the life of the lamp. By passing the light emitted from this lamp through suitable solutions, either the green radiation, desirable for ocular examination, or the indigo rays, so effective in photography, may be readily isolated.

Preparation of Alloys.—In studying the constitution of metallic alloys it is frequently necessary to examine a large number of alloys of various proportions of the same constituents, the object in view being to ascertain what proportions of the constituent metals correspond to critical structural changes. Hence the necessary preparation and examination of numerous alloys which have only a negative value. To obviate this Prof. Le Chatelier suggests superposing the two metals so that they will mix only in the vicinity of their contact. By preparing then a vertical section of the resulting mass, the metals may be observed alloyed in all proportions from one pure metal to the other. The results obtained in the case of alloys of aluminum and copper are illustrated in Figs. 8, 9, 10

and 11, which show the structure of different portions of the cross section of a small mass of alloy prepared by the superposition method.

Troostite and Sorbite.—In 1895 Mr. Osmond* described two constituents of steel, whose existence had not been previously discovered, and which he called respectively "troostite (in honor of the eminent French chemist, Troost), and "sorbite" (in honor of the distinguished English microscopist, Sorby, the pioneer of microscopic metallography). Mr. Osmond described troostite as being a transition form between martensite and pearlite, while he considered sorbite as a form of transition between ferrite and cementite. As Mr. Osmond himself now admits, these two constituents had not been sufficiently clearly defined; many metallographists fail to identify them satisfactorily, and some, no doubt, even questioned their existence; all steel microscopists are therefore, greatly indebted to Mr. Osmond for the clear description he now gives† of these constituents. Their existence as structural entities, at least in the case of troostite, can no longer be contested. In order to make the matter clear, it will be necessary to consider briefly the transformations which take place spontaneously when some carbonized iron is allowed to cool slowly from a high temperature to the atmospheric temperature. Steel, or rather carbonized iron, is composed after solidification of mixed crystals of γ iron holding the carbon in solution to which, considered as a structural entity, Mr. Osmond has given the name of austenite. It is well known that as the iron cools slowly it undergoes at certain temperatures, at least two allotropic changes which are accompanied by structural changes as well as by changes in the physical and chemical properties of the metal, and that the cold metal will be made up of ferrite (Fe) and of cementite (Fe_3C) both in the free state and forming a mechanical mixture (pearlite). During slow cooling then, austenite has changed to ferrite and cementite (pearlite). This transformation of austenite, however, does not take place abruptly at a certain temperature, but gradually, assuming some forms of transition more or less stable at certain temperatures. These forms of transition are in their order, according to Osmond: martensite, troostite and sorbite. To retain any of these forms in the cold metal it will be necessary to cool the steel at a rate which will be sufficiently slow to allow the desired constituent to be formed and sufficiently rapid to prevent its further transformation. The tendency of austenite to pass to martensite when the proper temperature is reached (*i.e.*, the temperature at which austenite ceases to be stable), is so great that it is only by quenching high carbon steel very suddenly that it can be retained in the cold metal, the carbon present assisting in its retention. Fig. 12, taken by Osmond, shows the structure of a steel with 1·50% C quenched in ice water. The light portions correspond to austenite, the dark to martensite. Part only of the austenite could be retained as such, the balance passing to martensite. By the water quenching operations as generally carried on in practice it is not austenite, but martensite, which is retained. The cooling is not rapid enough to prevent the austenite-martensite transformation. In low-carbon steel, moreover, austenite cannot be retained even by extremely quick cooling, for lack of carbon, which as already stated

* *Bulletin de la Société d'Encouragement*, May, 1895, p. 480. † *Ibid.*, November, 1900, p. 652.



Fig. 11. Crystals of $AlCu_3$.
Magnified 150 diameters.



Fig. 12. Steel containing 1.5 per cent. C., quenched in ice water.
Magnified 1000 diameters.

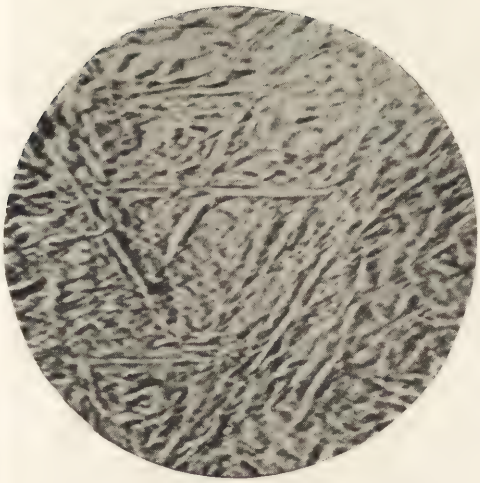


Fig. 13. Forged Steel.
Reheated to 825° C, and quenched at 720° C.
Combined polishing and etching.
Magnified 1000 diameters.

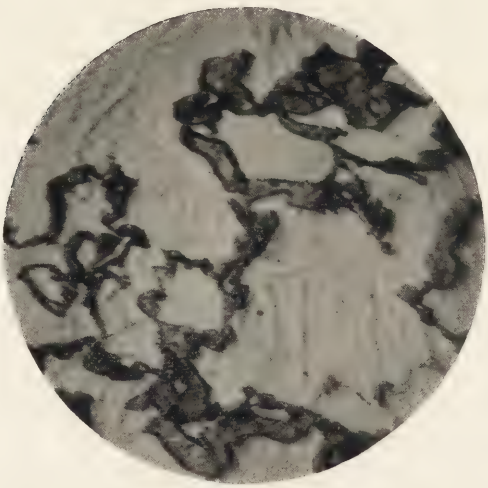


Fig. 14. Steel containing 0.45 per cent. C.
Heated to 730° C. and quenched in water during critical range.
Magnified 1000 diameters.

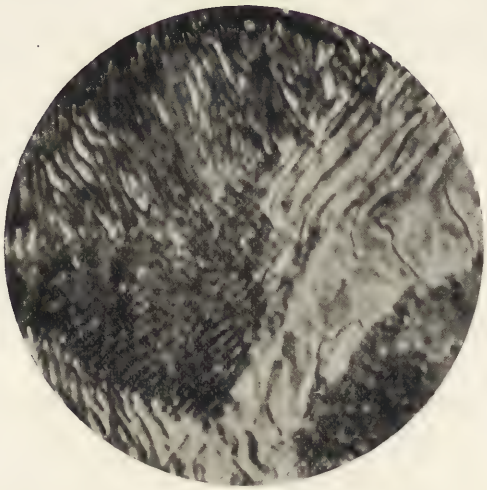


Fig. 15. Steel containing 1.24 per cent. C.
Reheated to 860° C. and slowly cooled
in the furnace.
Magnified 2000 diameters.

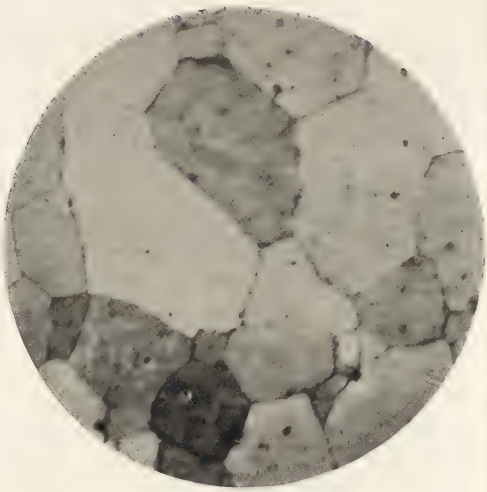


Fig. 16. Type of class 1.
Steels containing from 0 to 1.6 per cent P.
Magnified 50 diameters.



Fig. 17. Type of Class 2.
Iron containing 1.8 per cent. P.
Magnified 350 diameters.



Fig. 18. Type of Class 2.
Iron containing 8 per cent. P.
Magnified 250 diameters.

assists in retaining it. Fig. 13 illustrates the structure of steel containing 0·45% C, and quenched in water, it is made up entirely of martensite.

To retain the constituent troostite in the cold, the metal should be quenched in water while it is passing through its critical range, or quenched in oil from a temperature superior to that of the transformation, or it may be produced by proper reheating (tempering) of quenched samples, the martensite being thereby partially converted into troostite. Fig. 14 shows the structure of steel containing 0·45% C heated to 730°C. and quenched in water during the critical range. The dark constituent is troostite, the light background martensite with here and there a ferrite grain.

To produce sorbite, the rate of cooling should be still further reduced (quenching in molten lead, for instance), or the quenching take place at the end of the critical range, or it may be formed by reheating (tempering) quenched samples to a purple color. According to Osmond the cooling in air of pieces of small sections is sufficiently rapid to retain some sorbite in the metal, *i.e.,* to prevent the complete transformation of austentite into ferrite and cementite.

Fig. 15 illustrates the structure of a steel containing 1·24% C, reheated to 860°C. and slowly cooled in the furnace. The dark areas are sorbite, the light lamellar region, pearlite.

The Crystallography of Iron.—Mr. Osmond has published two scholarly and exhaustive memoirs (the last one in collaboration with Mr. Cartaud),* on the crystallography of iron. It is now well accepted that iron may exist in at least three allotropic states, γ, β, and α, each stable at a certain temperature, but the crystalline forms belonging to these different allotropic conditions were only imperfectly known. If it could be shown that iron assumes distinct crystalline forms, when allowed to crystallize at temperatures at which the various allotropic conditions are stable, it would constitute an irrefutable proof of the existence of these allotropic conditions. Such proof, however, is not needed. On the other hand should it be found that the three allotropic varieties assume exactly the same crystalline forms, it would in no way disprove their existence. Allotropy does not by any means imply a change of crystalline forms of the allotropic substance. In his first memoir Mr. Osmond reviews critically all the available data bearing upon this interesting subject. The conclusions which he reaches are in the main identical with those based upon some experiments of his own described in his second memoir, and referred to in the following pages. These experiments consisted essentially in the reduction of some ferrous chloride either through the action of hydrogen or of zinc vapor at temperatures at which the various allotropic conditions of iron are stable, *i.e.:*

Below 700°C. to cause the iron to crystallize in the α state. Between 750 and 860°C. to cause the iron to crystallize in the β state. Above 860°C. to cause the iron to crystallize in the γ state.

The transformations which take place during the further cooling of the metallic masses produced by the last two experiments will not affect the external forms of the crystals, and it will then be possible to study the crystalline

* *Annales des Mines*, January and August, 1900; *The Metallographist*, 1900, p. 181.

forms assumed by iron under its three allotropic conditions. These experiments conducted with great skill led the authors to the following conclusions:

"Iron in its three states, crystallizes in the cubic system.

"γ iron may assume all the combinations of the cube and the octahedron; never any modification along the edges; numerous *macles* with a′ as junction. In industrial iron more or less carburetted, the crystallization is preceded by a crystallitic phase more or less wide.

"β iron and α iron crystallize identically, which is a necessary condition, if not a sufficient condition, of their isomorphism, which, moreover, was further indicated by the progressive character of their mutual transformation. The crystalline form is the cube with frequent modifications, probably b^1 or b^2 along the edges. No modification on the angles.

"γ iron does not form an isomorphous mixture with β iron.

"The transformation of γ into β iron appears to be accompanied by an alteration of the positions of the planes of symmetry, at least in the case of carburized iron, but the size of the grains assumed by one of the allotropic varieties exerts a certain influence upon the dimensions of the grains resulting from the passage of the iron to the next allotropic state."

Iron and Phosphorus.—In my review for 1899* I alluded to some important work being carried on by Mr. J. E. Stead dealing with the detection under the microscope of the compounds formed by the phosphorus present in iron and steel. Mr. Stead has now embodied the results of his experiments in a most important paper,† the substance of which I shall endeavor to present here as concisely as possible.

Hundreds of samples containing from a trace up to a very large amount of phosphorus, and practically no carbon, were first prepared and examined through the microscope, their structure being in most cases made apparent by heating the polished samples as described in a previous section of this review. From the microscopical and other evidences described at length in the paper, the author is led to the following interesting and valuable conclusions:

1. When phosphorus is present in amount varying from traces to 1·70%, it forms a phosphide corresponding to the formula Fe_3P, which is held in solution by the iron (in solid solution, of course). All the metals used commercially, such as wrought iron and steels containing practically no carbon, may be included in this class. Fig. 16 illustrates the structure of all samples of this group, *i.e.*, nearly free from carbon and containing less than 1·70% P.

2. When the metal contains from 1·70 to 10·2% P, it consists of a saturated solution of Fe_3P in iron (1·70% P) and of a eutectic alloy containing about 10·2% P and made up of about 61% Fe_3 P and 39% of the saturated solution of Fe_3P in iron. To account readily for this structure and that of the following groups, it is only necessary to consider these metals as alloys of two constituents: one the phosphide Fe_3P and the other a saturated solution of Fe_3P in iron. It is well known that a certain class of binary alloys when solidifying give rise to the formation of a eutectic alloy, that is, to a mechanical mixture made up in

*THE MINERAL INDUSTRY, Vol. VIII., pp. 702-714. †*Journal of the Iron and Steel Institute*, No. II., 1900.

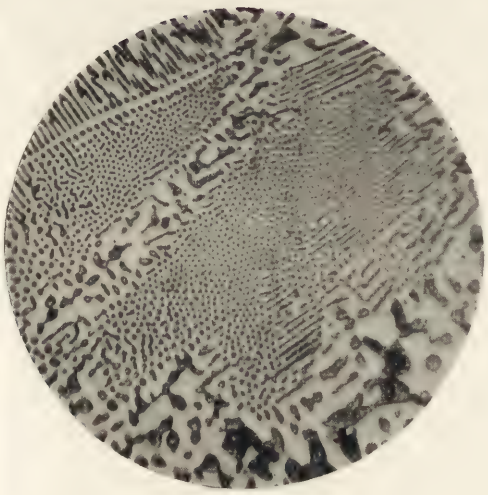


Fig. 19. Type of Class 2.
Iron containing 10.2 per cent. P.
Magnified 350 diameters.

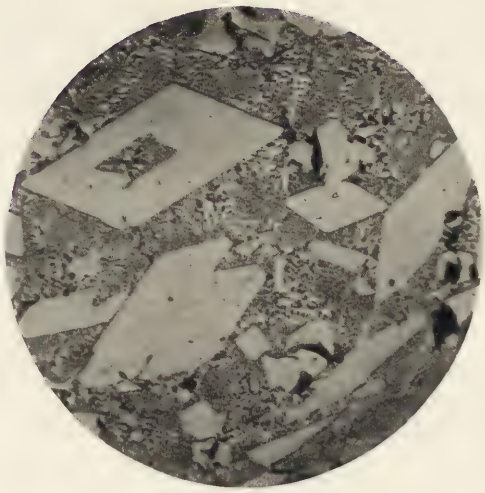


Fig. 20. Type of Class 2.
Iron containing 13.1 per cent. P.
Shows crystals of Fe_3 P. and eutectic.
Magnified 60 diameters.

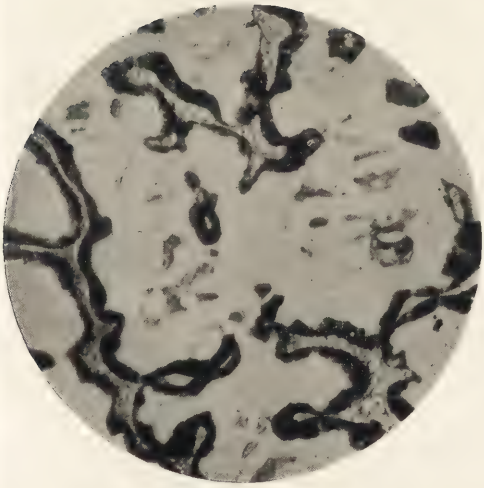


Fig. 21. Iron containing 1.54 per cent. P. and 0.13 per cent. C. Shows phosphide eutectic surrounded by pearlite.
Magnified 60 diameters.

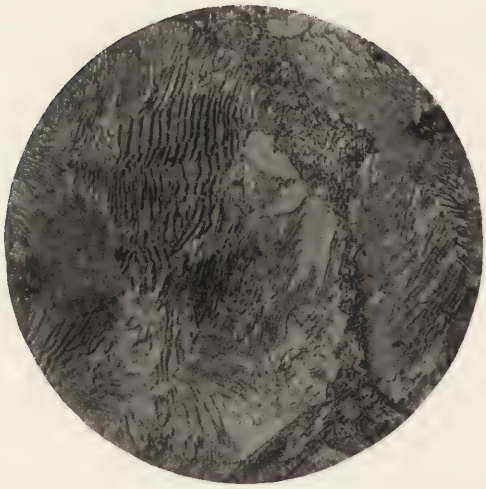


Fig. 22. Iron containing 1.7 per cent. P. and 0.71 per cent. C. Shows phosphide eutectic surrounding the grains of pearlite and ferrite.
Magnitude 250 diameters.

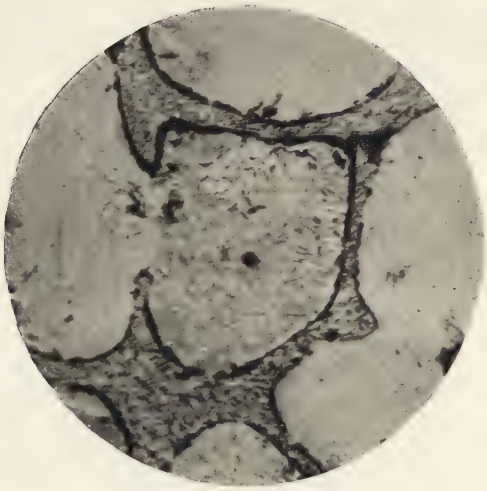


Fig. 23. Iron containing
1.7 per cent. P. and 1.4 per cent C.
Magnified 350 diameters.

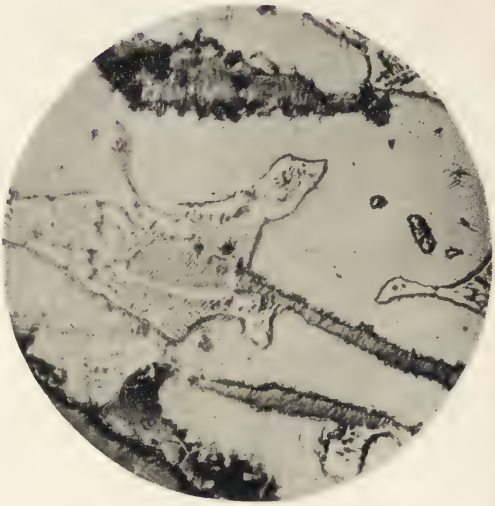


Fig. 24. Same as Fig. 26,
but magnified 250 diameters.
The compound character of the eutectic
is very evident.

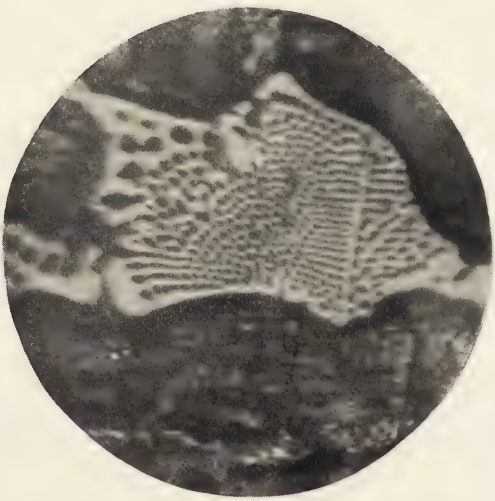


Fig. 25. Highly magnified photograph of one
of the phosphide eutectic areas. The ground
mass was darkened to show the eutectic
structure more clearly.
Magnified 400 diameters.



Fig. 26. Basic Pig Iron, containing 2.9 per
cent. P. Structure developed by "heat tinting"—
the dark flat areas are cementite.
The globular areas are pearlyte—the mottled
areas are the phosphide eutectic.
Magnified 200 diameters.

definite proportions, of extremely small plates alternately of one and the other constituents, the balance of the mass consisting of that constituent which is present in excess over the amount required to form the eutectic alloy. It is precisely what happens in the case of iron containing over 1·70% P. It is also what occurs in carburized iron considered as an alloy of iron and the carbide Fe_3C, giving rise to the eutectic alloy known as pearlite ($Fe+Fe_3C$), whose structure like that of all eutectic mixtures is so strikingly similar to the phosphide eutectic discovered by Mr. Stead. It would seem highly appropriate to designate this constituent by the name of *"steadite."*

Figs. 17, 18 and 19 illustrate the structure of iron containing respectively 1·8%, 8% and 10·2% P. The mottled constituent made up of two structural elements in close juxtaposition correspond in every case to the phosphide eutectic. The background of Fig. 17 and the clear regions of Fig. 18 are composed of the solid saturated solutions, while Fig. 19 is composed entirely of the eutectic alloy.

3. When the iron contains from 10·2% to 15·58% P it is composed of crystals of Fe_3P surrounded by the eutectic mixture just described, as illustrated in Fig. 20, in which the white angular areas represent Fe_3P and the background the eutectic alloy.

4. With a phosphorus content varying between 15·58 and 21·68%, Mr. Stead finds a phosphide of the formula Fe_2P associated with Fe_3P, the former increasing in amount and the latter decreasing as the phosphorus increases. Fe_3P, the author says, is easily attracted by the magnet, while Fe_2P is only slightly attracted.

The second part of Mr. Stead's paper is devoted to a study of the influence of carbon upon the structure of iron containing phosphorus and his conclusions are in part as follows:

"On melting saturated solid solutions of phosphide of iron in iron with carbon, the latter causes a separation of the phosphide near to the point of solidification, which appears in the solid metal as a eutectic in irregular-shaped areas, if the carbon present is small and in envelopes, increasing in thickness with the amount of carbon present, but is incapable of throwing the whole of the phosphide out of solution even when 3·5% C is present. A residuum always remains in solid solution. This residuum is smallest, however, when the carbon is at a maximum."

These conclusions are illustrated in Figs. 21, 22 and 23, showing the structure of some samples of iron with 1·7% P, and containing respectively 0·18, 0·71 and 1·4% C. He also finds that "a portion of the phosphide of iron in steels containing under 0·10% P is thrown out of solution by carbon when it exceeds 0·9%, and the phosphide so separated is liable to form a brittle cell structure enveloping the grains, yielding a more or less fragile mass. In such cases, however, the larger part of the phosphide remains in solid solution."

In the third part of his paper he deals with the structure of phosphoretic pig iron, which will be found finely illustrated in Figs. 24, 25 and 26. His conclusions are as follows:

"1. There are fusible eutectics in all pig irons containing phosphorus, and which have solidifying points of about 900°C.

"2. The free phosphide of iron can be left insoluble from such irons by dissolving them in cupric chloride (Schneider's method), or by nitric acid of specific gravity 1·20 in the cold. By attracting the magnetic portions of phosphide from the residue with a magnet, and further purifying what is attracted, almost pure Fe_3P is obtained.

"3. With the aid of the microscope it is possible to detect the phosphide eutectic in pig irons, even when the amount is as low as 0·03%.

"4. In white irons it is necessary to use the heat-tinting process to enable the cementite to be distinguished from the phosphide.

"5. The eutectics from such irons have a very complex constitution, containing phosphide of iron, carbide of iron in plates, pearlite, and silicide of iron. They deserve more careful study.

"6. The reason why phosphoretic pig irons are not more brittle than they are is because the eutectic separates into isolated segregations, and does not form continuous cells round the crystalline grains. When the phosphorus does not exceed 1·7% the metal is comparatively strong, but an addition of 0·3% reduces the strength materially, the reason of which is that the eutectic brittle areas in metal with 2% P approach each other closely, leaving less of the strong ground mass intervening."

Prof. Arnold and Mr. McWilliams had in a previous paper asserted that solid iron phosphide diffuses, under certain conditions, into solid iron, and to this subject the fourth part of Mr. Stead's paper is devoted. His results confirm the above conclusions and show that the quantity of phosphide which will diffuse is very considerable, amounting to about 1% of phosphorus. The temperature at which diffusion begins, however, has not been ascertained.

THE MANUFACTURE OF TITANIUM AND ITS ALLOYS.

By A. J. Rossi.

The effect of the presence of certain elements, such as manganese for instance, on the properties of iron and steel, naturally led metallurgists to study the effect of rarer metals when new specific qualities were required in the product. Nickel has been used with well-known results, and the rarer metals, chromium and tungsten, also have been utilized to impart to iron and steel very valuable properties for special applications. Metals of still greater rarity, as molybdenum and vanadium, have been incorporated with iron and steel experimentally and researches in this direction are still under progress. In order to produce certain of the above mentioned metals or their compounds with iron, and to render possible as well, their industrial application a new branch of metallurgy—the electric furnace—has been developed. Compared with iron all the rarer metals above mentioned with the exception of manganese, occur in smaller quantities or in fewer localities, and the cost of their ores is necessarily high for some, much higher for others and even prohibitory for certain of them.

The metal titanium was discovered by Klaproth in 1794. Its ores are very abundant and frequently occur associated with iron ores, all over the world, forming "mountain masses" in many of the United States—New York, Minnesota, Wisconsin, Michigan and North Carolina, and in foreign countries—Canada, Norway, Sweden, and Russia. The genesis of titanium ores has been ably studied by Prof. J. F. Kemp* and their occurrence in such enormous quantities fully explained. They may be obtained as cheap as iron ores and their tenor in titanic acid may reach as high as 50%. The mineral rutile, which is practically pure titanic acid (from 90 to 100% TiO_2) occurs in important quantities in many localities, and doubtless would be discovered in others were a demand established for it.

The association of titanium with iron in titaniferous iron ores is an advantage for the production of ferrotitanium. These ores are generally especially free

* "The Titaniferous Ores of the Adirondacks," *United States Geological Survey, XIX. Annual Report*, 1897-98, Part III. "Economic Geology," by J. F. Kemp. "A Brief Review of Titaniferous Magnetites," *School of Mines Quarterly*, Vol. XXI., No. 1, November, 1899.

from sulphur and phosphorus and contain but little silica and gangue. Their occurrence is so abundant that it is a simple matter to select the proper materials for a source of titanium, or even for the production of pig iron in the blast furnace. These ores have been successfully smelted by blast furnaces in England, Sweden and the United States, but, leaving aside all question of the practicability or economy of their smelting as foreign to the present article, the remarkable qualities, not only of the pig iron produced, but also of its admixture, when refined, with other pig metals, are facts well known and substantiated by numerous authorities. With this in view, it was natural that titanium should be regarded as a "seasoning" for iron and steel. If its value in this direction were positively established, its use would be well indicated. The ores are abundant, widely distributed and cheap, and for its industrial production the metallurgist would have but to solve the simple question of producing the metal or ferro alloy at a cost industrially admissible.

Titanium oxide is one of the most refractory of all oxides, and is practically unreducible by carbon at the temperature of either the blast furnace for iron or the open-hearth furnace for steel. When found in pig iron which has been produced from titaniferous ores—up to a few tenths of a per cent., its presence, according to my observations, is due to reaction other than the direct reduction of its oxide by carbon. In Moissan's well-known experiments in the electric furnace, titanium carbide was produced in somewhat important quantities, and its subsequent refining in order to remove the greater part of the carbon and thereby obtain the titanium in the metallic state, rendered the cost so great as to be prohibitory for industrial applications.

It is my object in this article to describe the methods devised for obtaining ferrotitanium in large quantities at a cost sufficiently low to admit of industrial use. These methods are of two classes: (1) the use of a bath of molten aluminum as a reducing agent, by which ferrotitanium is produced containing from 0·1 to 0·5% C, from 10 to 75% Ti and practically free from phosphorus and sulphur—an alloy well suited to the treatment of steel, and (2) the use of carbon as a reducing agent, by which an alloy is obtained with 10% Ti or more as desired, that is well suited to the treatment of cast iron. The carbon contained (which is really of no consequence in this case) exists as graphite and is not in the combined state and the titanium therefore is in the metallic state and not as a carbide. By this method there have also been obtained alloys of titanium with copper that possess remarkable physical properties, as will be detailed later in this article. By a special process titaniferous ores containing but 6 to 8% Ti (10 to 14% T_1O_2) have yielded a ferrotitanium as high as 75% Ti, a fact of great commercial importance as it is thus not necessary to depend on ores rich in titanium, but choice may be made with reference to other constituents as well.

HEAT.—The generation of intense heat, estimated as high as 3,000°C. may be obtained by means other than the electric furnace. Dr. Hans Goldschmidt, by a very ingenious method, has succeeded in producing on a large scale what was formerly a laboratory reaction. His new method of obtaining a high temperature is called in Europe "Alumino-thermics" and it has been successfully applied

to generate in a limited space at a given point, sufficient heat to cause a soldering of pipes, rails, imperfect castings of steel or cast iron and similar articles, as well as the melting of refractory substances,* and it will be discussed here only so far as it bears on the subject of reducing metallic oxides and on the production of metals and their ferro compounds. For the past 50 years it has been known that aluminum in powder when used under certain conditions would reduce the most refractory oxides. The principle of thermo-chemistry involved in this case is that of "maximum work," *viz.:* In general a metal or element of which the heat of combination for each atom of oxygen is greater than that of another element, will reduce to the metallic state the oxide of the latter; in other words, that the reaction will occur, or at least, can be foreseen, whenever in the equation: $R+R'=RO+R'$ the heat of formation of RO less that of R'O will give a positive number. In the case of aluminum $Al_2+R_2O_3=Al_2O_3+R_2$ the reaction is exothermic. To secure these results it was formerly considered necessary to use the aluminum in a finely divided state, in fact, as an impalpable powder, which was intimately mixed with the powdered oxide to be reduced. To start the reaction the temperature was raised at some point, but when once started, it continued by contiguity throughout the mass without the assistance of external heat. In some cases the reaction was so violent as to cause the ejection of the material from the vessel in which the operation was being conducted. The work of Goldschmidt avoided these difficulties, the action being more or less continuous and capable of industrial application. To ignite the mass he uses a primer composed of a mixture of powdered aluminum with sodium or barium peroxide which is agglomerated in a small ball and inserted into the mixture of powdered aluminum and oxide to be reduced, generally contained in a graphite or other refractory crucible. The primer itself is ignited by a ribbon of magnesium. When heat alone is desired, the primer is placed on the top of the material to be heated.

If a metal or other substance is to be raised to a given temperature, perhaps to be melted, the amount of aluminum required is easily calculated, enough being used so that the positive heat disengaged by the exothermic reaction will be sufficient; but when refractory oxides are to be reduced, not only must sufficient aluminum be used to start the reaction and to raise the temperature of the mass to the proper degree, but the metallic oxide to be reduced must be mixed with sufficient aluminum to satisfy the chemical equation $Al_2+R_2O_3=Al_2O_3+R_2$. One hundred pounds of ferric oxide requires about 33·3 lb. aluminum; chromic oxide about the same amount, while titanic oxide calls for nearly 50 lb. of aluminum. While the Goldschmidt method is good in principle, it is necessarily expensive and renders the cost of the metal or ferrometal obtained by it too high for extensive industrial uses. The cost of aluminum in the powdered state is from seven to ten times as much as the ingot, depending on purity. The metal or ferrometal produced contains any impurity of the titanium ore as well as some of the aluminum itself which, owing to the rapidity of the reaction, causes the reduced metal to melt and almost immediately solidify. The constituents of the vessel in which the operation is made will also appear in

* THE MINERAL INDUSTRY, Vol. IX., p. 28, 1900; *Engineering and Mining Journal*, Aug. 25, 1900.

the metal or alloy; silicon, if an earthy crucible be used; carbon, if a graphite one; and the constituents of the gangue of the metallic oxides will also appear to some extent in the product as they are simultaneously reduced with iron oxide by the aluminum. In other words, unless all the materials used in the Goldschmidt process be absolutely pure, the product will not be free from carbon, silicon, phosphorus or sulphur and is apt to contain a large amount of aluminum. This is readily seen by the following analysis of a ferrotitanium made in Europe by this process: (1) 24% ferrotitanium (cost $1·20 per lb. in lots not less than 100 lb.) gave C, 0·434%; Ti, 24·19%; Al, 5·94%; Si, 1·03%; P and S present, but small. (2) A 10% titanium alloy (quoted in large quantities at 90c. to $1 per lb.) gave C, 0·745%; Ti, 11·05%; Al, 9·96%; Si, 1·25%; P and S present, but small. The presence of aluminum and other substances in these alloys is objectionable and can only be removed by a second treatment with iron oxide, using aluminum as a source of heat, or by remelting in an electric furnace, which involves increased expense.

I should remark here that within certain limits the importance of silicon, carbon and phosphorus in an alloy appears to have been considerably overrated. If 2 lb. of the 25% Ti alloy of 4% C, 2% Si and 0·09% P be added to a 100 lb. charge for crucible steel in order that the latter should contain about 0·5% Ti, the addition of the objectionable constituents would be only 0·08 lb. C, 0·04 lb. Si and 0·0018 lb. P.

I have found that it is not necessary to use powdered aluminum in order to secure the reaction of the metal on metallic oxides. A bath of aluminum, if maintained at a sufficiently high temperature by an electric current, will produce the same results at a cost practically proportionate to the prices of aluminum in powder and as ingot or scrap, the extra cost for the external heating being comparatively insignificant. Quantities of ferrotitanium up to 250 lb. have been made in a single furnace in one operation; and with increased size the amount could easily be raised to 500 lb. The bath of aluminum and the material on which it is to act having been raised to the maximum temperature by the external heat, the action proceeds of itself, so to speak, and the heat supply may be moderated and later increased in order to keep the metal or its ferroalloy in a molten condition as well as the aluminous slag which separates from it. If necessary, it is then an easy matter to remove any aluminum contained in the product, by the addition of iron oxide, and further refining may be conducted by adding other suitable materials.

The heat of the combination of an element with oxygen varies with the temperature; as is generally the case also for specific heats and other physical properties. It generally decreases, although it may at first increase, then diminish and again increase. Empirical formulas giving the heats of formation of aluminum at different temperatures have been calculated, which show that it increases with the temperature up to a certain point where it is a maximum and then decreases very rapidly. The curve representing this equation resembles a parabola. In a similar manner the curve representing the changed specific heats of carbon monoxide has been calculated and is represented by a line nearly straight. Referring to the reaction, $Al_2O_3+3C=3CO+Al_2$, it has been

positively ascertained that, while the heat of formation of 3CO at a given temperature is only one-fifth that of the heat of formation of alumina, carbon would decompose alumina at some particular temperature, shown precisely by the intersection of the nearly straight line and the parabolic curve. In the same line of ideas, a given metal, which at a certain temperature cannot reduce titanium or other oxides, may do so at a higher temperature at which the curve representing the heat of formation of titanic (or other) oxide at different temperatures, would be intersected by that representing the heat of formation of the oxide of the given metal.

Other conditions of the metal or oxide, as volatility, etc., may render this property, if it existed *a priori,* unavailable for practical use. However, following this line of thought with aluminum, I have reduced titanic oxide by zinc, and obtained a ferrotitanium with as much as 4·90 and even 7% Ti. While zinc in powder or ingots is comparatively much cheaper than aluminum, its volatility and other drawbacks militate against its use, although the zinc oxide produced could be condensed and collected.

The use of the electric furnace to secure a proper and easily controllable temperature so necessary for the attainment of the maximum intensity of reaction has been most satisfactory, and while the disposition of the furnace may vary greatly, the one used was similar to the well-known Siemens type. It consists essentially of a large block of agglomerated graphite encased in a wrought-iron shell and provided with a central cavity forming a crucible of sufficient size to charge in one operation the total amount of material to be treated. The wrought-iron shell forming the cathode, is properly connected with one of the busbars of the current. Into the crucible can be lowered a single or multiple carbon of the proper dimensions to carry the current adopted, there being sufficent room between it and the crucible sides to contain the charge. The carbon forming the anode is connected with a copper cross-bar having guides at each end, which allows it to slide between two vertical posts. The cross-bar is connected with the other busbar of the current by a flexible cable and with the attached carbons may be moved vertically by a pulley arrangement. The remaining details of the furnace were developed by practice and aided the easy and rapid removal of the cakes of alloy and the handling of the carbons, by which a saving in labor was effected, and a less waste of carbon with a consequent reduction of cost. A current of 25 alternations per minute was used but the apparatus may be operated by a continuous current as well.

The details of working are as follows: The carbon electrodes having been elevated, aluminum in waffles, scrap or ingot, is charged into the cavity, together with a certain amount of scrap iron, depending upon the composition of the ores and the percentage of titanium required in the product. The carbons are then lowered to make the contact with the aluminum, the current turned on and the remainder of the charge shoveled into the space between the carbon and the sides of the crucible. According to the product desired, the charge consists of coarsely crushed titaniferous ores of high or low titanium content, or a mixture of titaniferous ores with rutile; rutile alone, or a "titanium concentrate,"

which last is described later in this article. The temperature of the furnace soon rises to the point at which the aluminum and scrap iron, or aluminum alone, are in complete fusion. A vivid incandescence then occurs and alumina begins to go off in fumes. The operation proceeds almost of itself and the intensity of the current is moderated by the raising of the carbons so as to maintain it at some certain point shown by practice to be the most satisfactory. It is then increased to keep the resultant alloy or metal in a melted state. If the furnace has been closed at the top, even loosely, most of the alumina resulting from the oxidation of the aluminum (at the expense of the metallic oxides in the charge) will be found as a molten slag on the top of the molten alloy. Both of these products may be removed through proper openings if the operation be continuous. The slag assaying from 80 to 85% Al_2O_3 combined with the earthy gangue of the ores, contains at least 90% of the aluminum charged. When the operation is intermittent the furnace is cooled and by proper disposition of the sides the cakes of alloy with superimposed slag are easily removed. Under proper conditions the slag is easily and cleanly detached from the metallic part and in this way cakes of alloy of 250-lb. weight have been produced in one furnace operating from 1·5 to 2 hours. With the four furnaces in use at Buffalo, 1 ton of alloy could easily be made in 24 hours. The molten alloy may be refined by the addition of titaniferous ores in the furnace, the current being maintained for a short time. I have done this frequently when a purer product was desired.

A proper adjustment of ores and scrap iron has yielded alloys containing from 10 to 75% Ti, which were practically free from carbon and low in phosphorus and sulphur, the ores being especially free from these elements. In making the low alloys, the rutile and the scrap iron used were the principal sources of even the small amount of phosphorus contained in the resultant alloy. The subjoined table shows the composition of a number of alloys produced:

ANALYSIS OF FERROTITANIUM ALLOYS.

	%	%	%	%	%	%	%	%	% (a)	% (a)	%
Titanium	35·24	35·64	10·81	10·06	21·52	28·64	25·17	10·28	75·84	53·92	47·70
Carbon	0·687	0·750	0·848	0·810	0·790	0·184	0·590	0·284	0·311	0·291	0·591
Phosphorus	0·07	0·06	0·06	0·06	0·06	0·06	0·06	0·09	0·042	0·059	0·081
Sulphur	0·015						0·011	0·010			

(a) From the igneous "concentrates" obtained from ores.

In making these alloys two classes of ores were used, complete analyses of which are given later in this article. The Canadian ore contained about 24% Ti (40% TiO_2) and about 35% Fe. From this an alloy of from 35 to 40% Ti was easily made and by the proper addition of scrap iron the product contained any desired percentage of titanium. The ore from the Adirondack region was the purest and contained from 8·5 to 9% Ti (14 to 15% TiO_2) and from 58 to 60% Fe. Without the addition of scrap it yielded a 13% titanium alloy. In a few exceptional cases rutile containing 54% Ti (90% TiO_2) and 5 to 6% Fe was used by adding it to the Canadian ores and from this mixture an alloy containing from 65 to 69% Ti was obtained (the cost of rutile is quoted at $300 to $400 per ton).

In all these cases, excepting with rutile, it was necessary to calculate the quantity to be added so as to satisfy the equation

$$Al_2+Fe_2O_3=Al_2O_3+Fe_2.$$

That is, already stated, about 0·33 lb. aluminum per pound of iron oxide in the ore. A reduction of the expense of aluminum was made by using, in place of the titaniferous ores, a "titanium concentrate," which was obtained from them. In this way the Adirondack ore, with 9% Ti (15% TiO_2), produced an alloy of 75·84% Ti and reduced the amount of aluminum required to that practically necessary for the reduction of the titanium oxide only. At the same time a by-product was obtained the value of which offset to a great extent the final cost of the alloy. Whenever the presence of carbon in comparatively large quantities in the alloy is of no special consequence, as for instance when it is intended to season cast-iron or high carbon steel, the aluminum may be replaced by carbon as a reducer. In this manner alloys ranging from 10 to 25% Ti and above were obtained according to the relative quantity and quality of ores and scrap added. In all cases, however, where carbon was used as a reducing agent for the metallic oxides of the ores, it was necessary to operate with a bath of iron in order to secure satisfactory and economical results. This was done by charging a certain amount of scrap iron in the furnace, melting it to form a supporting bath and adding the charge of coarsely granulated ore and charcoal, intimately mixed. The titanium as it is gradually reduced from the oxide by the carbon dissolves in the bath as it is formed, and the iron reduced from the iron oxide mixes with the other constituents of the molten mass. In these conditions, the alloy contains the carbon almost exclusively in the graphitic state and the titanium in the metallic state, and not as carbide; a fact of considerable importance, as it bears directly on the properties of the alloy thus obtained. Much of this carbon may be readily removed mechanically by crushing the alloy into coarse powder.

The conditions attending the method of "concentration" are briefly outlined as follows: A charge of Adirondack ore and carbon is made in such proportion as to reduce the iron oxide but not the titanic acid. This mixture is submitted to an electric current of sufficiently low intensity (a few hundred amperes) to produce a temperature approximating that admissible in a blast furnace, which is below that at which titanic acid may be reduced by carbon. If sufficient quicklime or calcite be present to form with the titanic acid of the ore a titanate of lime as well as of the other bases present in the ore, there will be obtained: (1) a pig iron particularly free from sulphur and phosphorus that contains the greater part of the silicon reduced from the silica of the ores; (2) a slag which contains practically all the titanic acid of the ores combined with the bases with but a small percentage of iron, thus forming an "igneous concentrate," so to speak, of lower silica content than the ore itself. This concentrate is an excellent material for the production of titanium alloys. By operating in this manner on Adirondack or Canadian ores with a proper addition of lime (13 and 30% respectively) a concentrate was obtained of 35% Ti and 2 to 3% Fe, and a pig iron. Analyses of these materials are given in the table on page 723.

By treating this concentrate in the electric furnace, with aluminum as a reducing agent, similar to the treatment of ore, it is evident that, on the score of iron oxide, but an insignificant amount of aluminum will be required, and practically the total amount required will be the amount needed for the reduction of the titanic acid only. The percentage of titanium in the resultant alloy will depend upon the amount of scrap iron added. With a concentrate containing 35% Ti (58 to 59% TiO_2) and 3% Fe, no scrap being added, a product could be obtained as high as 92% Ti. No difficulty was shown in producing an alloy of 75·84% Ti by the addition of 5 to 10 lb. of scrap iron.

The alumina slags produced, both in the treatment of concentrate and ores, are sufficiently hard to scratch glass deeply, and might form the basis of an excellent abrasive material, being an impure artificial corundum of greater hardness than the natural mineral. It might also be used as an original material for the manufacture of aluminum by treating it similarly to bauxite. In this manner, a large percentage of the aluminum used as a reducer, would be recuperated in another form and would tend to diminish the original cost of the alloy made from aluminum.

The carbon alloys can be made at a cost which renders their use on a large industrial scale, practical and economical, and those from the treatment of concentrates by aluminum for a small additional cost per pound. It is readily seen that the furnace for making the concentrates may be continuous in operation, running out the slag concentrate at one level and the pig metal at another. In this case the products have a constant composition which is not so with the alloys, as the percentage of titanium during the operation increases as it proceeds, and as the titanic acid of the ore is reduced, either by carbon or aluminum. Summarizing, it is thus seen that the method of concentration yields (1) practically all the iron of the original iron ore, as pig metal of a special value on account of its freedom from phosphorus and sulphur, similar to the pig iron obtained with charcoal from titaniferous ores; (2) a concentrate of the titanic acid in a product practically free from iron and lower in silica than the original ores; (3) from this concentrate may be produced a ferrotitanium free from carbon and as high in titanium content as desired at the least possible expense of aluminum used as a reducer; (4) an aluminate slag, excellent as an abrasive material or as a source of alumina in which 80 to 90% of the aluminum originally charged is found. From this may be seen the many advantages possessed by this process, as compared with the process using aluminum in powder.

The subjoined table includes analyses of materials used in the manufacture of ferrotitanium and partial analyses of the products:

ANALYSIS OF TITANIFEROUS IRON ORES.

Locality.	S_1O_2.	T_1O_2.	=(Ti).	Fe_3O_4.	=(Fe).	CaO.	MgO.	Al_2O_3.	P.	S.	Total.
Adirondack (Mill Pond).....	1·5	14·5	8·7	80·01	58	0·4	2	2·1	0·017	0·025	100·552
Canadian	2·5	36·28	21·75	50·76	35·53	1·7	3·32	3·44	0·043	0·073	98·116

ANALYSES OF "CONCENTRATES" OBTAINED BY THE TREATMENT OF ORES WITH LIME FOR PIG METAL.

	%	%	%	%	%	%	Average %
Titanic acid (TiO_2)	54·26	58·10	58·64	60·06	53·70	59·84	57·41
Alumina (Al_2O_3)	2·30	2·43	6·32	5·54	4·04	3·46	4·01
Ferrous oxide (FeO)	4·00	4·01	2·34	4·50	4·26	5·14	4·04
Magnesia (MgO)	2·75	2·85	4·50	2·85	3·50	2·79	3·12
Lime (CaO)	33·16	28·50	25·62	26·06	25·96	27·62	27·80
Silica, insoluble residue	2·50	4·11	2·80	2·06	7·44	2·00	3·49
Carbon							
Total	98·97	99·89	100·22	101·07	98·90	100·85	99·87

ANALYSIS OF PIG METAL.—Carbon, 3·676% (practically all combined).

ANALYSIS OF ALUMINATE SLAGS.—(Produced in the treatment of concentrates as for the production of alloys): Averaging 2·83% Fe and 34·45% Ti. Average analysis: Al_2O_3, 62·66%; CaO, 23·40%; FeO, 8·50%; MgO, 2·47%; TiO_2, SiO_2, insoluble, 3·30%; total, 101·33%.

ANALYSES OF ALUMINATE SLAGS PRODUCED IN THE DIRECT TREATMENT OF ORES BY ALUMINUM.

	%	%	%	%	%	Average %
Insoluble residue (C, SiO_2, TiO_2)	6·42	8·00	2·88	3·90	4·30	5·10
Alumina (Al_2O_3)	75·50	82·22	84·85	87·10	86·30	83·19
Lime (CaO)	Trace.	*Nil.*	Trace.	2·30	Trace.	0·45
Magnesia (MgO)	16·60	5·12	6·97	1·05	1·09	6·16
Iron oxide (FeO)	1·15	5·50	4·87	5·80	8·40	5·14
Total	99·67	100·84	99·57	100·15	100·09	100·04

According to Joule's law, which gives the quantity of heat furnished by an electric current through a conductor, the temperature could rise indefinitely with the number of amperes, but it is limited by the heat of formation of carbon vapors, estimated to be about 3,500°C. A current of 10 amperes will easily accomplish this, hence the intensity of the heat secured in an electric arc furnace depends primarily on the intensity of the current; *cæteris paribus,* but also on the amount of work the current will do. A small arc will secure the highest temperature at one point only in a very limited zone, while a powerful current is required to generate and maintain in an *enceinte* an average temperature sufficient for certain desired reactions and it should be more intense, depending upon the amount of work to be accomplished in a given time, the amount of material to be treated and the consequent diminution of *enceinte.*

The maintenance of even 4,000 amperes in a cavity too large may not suffice to cause the reduction even of iron oxide by carbon in the parts of the charge the most remote from the direct action of the arc unless an undue time be allowed for the temperature to become equalized throughout. For these reasons the intensity of the current used by me and the time of its application varied between wide limits, according to the difficulty of reduction, the refractory properties and the mass of material treated.

The alloys made with aluminum were silvery-white and presented in the fracture large brilliant crystalline facets in the lower alloys, but the higher the

percentage of titanium, the finer the grain and the color became less white and lustrous. The brittleness and hardness also was increased with the higher percentage Ti; all the alloys, however, scratch and cut glass, and tough as they are in large cakes (up to 250 lb.), when once broken into small fragments they may be readily powdered coarsely or even quite fine in a steel mortar, the higher alloys giving the finer product.

The alloys reduced by carbon were generally low in Ti content, averaging from 10 to 12% Ti; a few were made as high as 25%. Alloys higher than this could be obtained but they were not desired for the special purpose required. The color of these carbon alloys was dark steel gray, very much like No. 1 graphitic pig iron, but very lustrous; the fracture showed fine crystalline facets of graphite that sparkled like diamonds. The alloys were much softer than those made with aluminum but still would scratch glass and were remarkably tough under the heaviest blows. They would flatten and forge before separating into small fragments, which could then be reduced to coarse grains and to powder with great difficulty, as the small grains again flattened without breaking, in the mortar. The carbon in these alloys is mostly in the graphitic state while the titanium is in the metallic state and not as carbide.

All the alloys made were considerably lighter than steel or cast iron, which could be easily foreseen, as the specific gravity of titanium, according to Moissan, is 4·87. The specific gravity of an alloy reduced by aluminum containing 38% Ti, 4·45% Al, less than 1% C, was 6·16 and one containing 75% Ti was 5·49.

It is stated by Moissan that titanium "dissolves in all proportions in iron," and the presence of titanium in the alloy in a metallic state and not as carbide is, therefore, a favorable factor for its incorporation into iron or steel. These alloys are less fusible in proportion to the titanium content and for this reason in all tests made, especially with cast iron, the alloys lower in titanium were preferably used.

The subjoined table contains the analyses of some of these alloys for their carbon, silicon and titanium content. The phosphorus and sulphur are fully as low as in the aluminum alloys. This was ascertained by a few special analyses.

ANALYSIS OF FERROTITANIUM ALLOYS.

Components.	Special.	Made from Ore.						Made from Concentrates.			
	%	%	%	%	%	%	%	%	%	%	%
Total carbon	9·299	7·286	5·801	6·178	7·012	6·234		6·002			
Graphite	9·179	7·026		6·083	6·871						
Combined carbon	0·120	0·260		0·095	0·141						
Titanium	19·23	12·27	10·96	12·54	18·41	12·42	13·02	12·54	11·55	11·96	10·80
Silicon	1·76	0·76	0·68	0·61		1·06	0.88	0·50			

THE EFFECT OF TITANIUM ON IRON AND STEEL.—Both classes of alloys have been used experimentally in connection with iron and steel, generally applying those reduced with aluminum for steel and with carbon for cast iron. My experiments so far have been limited to crucible steel, but many others are in progress both in this country and abroad with open-hearth and Bessemer steel as well. A great advance has been made in the experiments with cast iron and

the results of numerous tests by different operators show a remarkable concordance in the improvement in the strength of the metal, be the original pig iron good, bad or indifferent.

Up to the present time the alloy has been added to the pig metal contained in crucibles or in a ladle before pouring, although extensive tests are contemplated in connection with direct addition in the cupola. The best results were obtained by the use of the alloys in a powdered condition. They are lighter than the metals to which they are added and tend to float on the surface of the molten mass, where they remain partly inactive. To overcome this objection it was found advisable, particularly with crucible steel, to fill a wrought-iron or cast-iron pipe with the alloy, closed at both ends, dropping it in the liquid mass similar to the method used with ferromolybdenum.

Experiments with Cast Iron.—In the tests described below, identical dimensions and shapes of test bars were adopted to make the results comparable. For transverse strength the bars were 13 in. long and 1×1 in. in section, testing 12 in. between bearings. For tensile strength the bars were 1 in. in diameter and 18 in. long. In every case three round bars and three square bars were cast from the original pig under experiment, as well as from the same pig after treatment with alloy. The results of the machine testing as given in the subjoined table, were the average of three bars in each case. Analyses of the pig metal before and after treatment are also given, as far as practicable.

When operating in a crucible, a first charge of from 50 to 100 lb. of the pig metal was melted and cast into bars. Then to another charge the alloy was added as specified in each case under the following conditions: In small lumps, cold; in lumps after the metal had become melted; in coarse grains, cold, either before or after the metal had become melted. In a special case the alloy was heated almost to whiteness before its addition to the molten pig iron. As may be observed the results varied little whenever the amount of alloy added was completely dissolved, except when added cold and in lumps, in which case the heating was prolonged and it was necessary to raise the temperature slightly higher. In the tests made by outsiders one experiment was conducted in a crucible and one directly in the ladle before pouring. In the latter case 700 lb. of car-wheel iron was taken from the large ladle containing the metal from the cupola. The pouring ladle was partly filled and the alloy in rather large lumps added cold. The ladle was then filled with hot pig iron and the mass stirred with a rod and immediately cast into a wheel, taking samples of the metal in a small ladle for test bars and chill test blocks. From the results it seemed that the transverse strength was increased from 20 to 30%, averaging 25%, and the tensile strength was increased from 30 to 60%. In the case of the wheel, the chill cast from the treated metal was much stronger than the one cast from the original pig. In the latter case at the chill test block it was ill defined and mottled beyond the white part, while in that of the metal treated with the alloy it was decidedly gray, well defined in the white part and fully equal to the average chill considered admissible. The wheels cast from the treated metal showed remarkable strength and withstood very satisfactorily the severe thermal test required by some railroad companies. In one case it was reported to me that

the treated metal remained liquid in the molds decidedly longer than the untreated. Its specific heat must be higher as that of the alloy itself is very high.

PROPERTIES OF PIG IRON TREATED WITH ALLOY CONTAINING FROM 10 TO 12% TITANIUM.

	Transverse Strength, lb. per sq. in.	Tensile Deflection at center, in.	Tensile Strength, lb. per sq. in.	Increase.		
				Transverse Strength.	Tensile Strength.	Deflection.
Alloy added in Crucible:				%	%	%
1. Original pig (*A*) (*a*)	2,510	0·10	25,480			
2. After 5% addition of alloy	2,950	0·13	30,000	18	18	30
3. After 8% addition of alloy	3,100	0·13	30,300	23	19·6	30
4. Original pig (*B*)	1,700	0·07	11,200			
5. After 4% addition of alloy	2,750	0·12	18,000	60	60	70
6. Original pig (*C*) (*b*)	1,940	0·0866	13,560	28		
7. After 5% addition of alloy	2,480	0·131	20,300	28	50	
8. After 5% addition of alloy	2,450	0·13	21,400	28	60	
9. After 8% addition of alloy	2,480	0·13	22 600	28	66	
10. Original pig (*D*) (*d*)	2,046	0·110	20,372			
11. After 4% addition of alloy	2,710	0·14	26,409	32	30	
Alloy added in Ladle:						
12. Original pig (*E*) (*c*)	2,200		22,500	23		
13. After 4% addition of alloy	2,710		28,200	23	25	
14. Original pig (*F*) (*average*)	3,084					
15. After 4% addition of alloy	3,758			22		
16. Original Pig (*F*) (*maximum*)	3,388					
17. After 4% addition of alloy	3,900			17		
18. Original pig (*G*) (*e*) (*average*)	3,200					
19. After 5% addition of alloy	3,900			22		

(*a*) Analysis of original pig (*A*): Combined carbon (*C*), 0·758%; graphitic carbon (*G*), 3·098%; total, 3·856%. ($\frac{C}{G}$=24·4%.) Phosphorus, 0·88%; sulphur, 0·052%. After 5% addition of 10% alloy the analysis was: Combined carbon, 0·709%; graphitic carbon (*G*), 2·959%; total, 3·668%. ($\frac{C}{G}$=24%.) Phosphorus, 0·815%; sulphur, 0·0518%; titanium, 0·345%. (*b*) Crushing strength of 1″ cube, original pig (*C*), 90,000 lb.; after 4% addition of alloy, 110,000 lb.; increase, 22%. (*c*) Results calculated from larger size test to standard size, 1″×1″×12″ between bearings. Formula: $\frac{RI}{n}$=ft. the bending moment. (*d*) Analysis of original pig (*D*): Graphitic C, 2·98%; combined C, 0·60%; Mn, 0·78%; P, 0·52%; S, 0·052%; Si, 0·052%. Original pig experiment made by Cramp. (*e*) Analysis of original pig (*G*): Graphitic C, not determined; combined C, 1·50%; Mn, 0·62%; P, 0·39%; S, 0·075%; Si, 0·85%.

As may be seen from these tests an addition of from 4 to 5% of the alloy gave very satisfactory results. While larger additions appear to increase the strength still more it is not directly in proportion to the amount added, although under special conditions where cost is a secondary consideration, the larger addition of alloy might be justified.

The average requirements for ordnance gun metal (experiments of Major H. Wade), are as follows: No. 1 extra, tensile strength, 28,805 lb. per sq. in.; No. 2 tough, 24,767 lb.; No. 3 good, 20,148 lb. In all cases the tensile strength of good pig iron originally of about 20,000 lb. per sq. in. has been increased to 27,000 or 28,000 lb. by the addition of the alloy, and weak irons of 14,000 lb. tensile strength have been brought to the 20,000-lb. limit. Unfortunately in the establishment where these tests were made, bars for tensile strength were not cast in the cases of the good mixtures, which showed some 3,200 lb. in the breaking strength of the original metal as compared with 3,800 or 3,900 lb. in the treated metal, but if it is assumed that the tensile strength is approximately ten times the transverse strength—a proportion which is borne out by the above experiments and generally assumed—an estimated tensile strength of 30,000 lb. would be obtained.

In these experiments the alloy was added in cold lumps either with the cold pig iron or after it had become melted in the crucible. This method of addition is somewhat wasteful, as, for reasons stated above, the alloy floats on the molten metal and becomes oxidized with consequent loss. It would have been more satisfactory had the alloy been enclosed in a cast-iron pipe before its introduction into the bath of molten metal. In an experiment in which the alloy was added in this latter manner, analysis showed the resultant metal to contain 1·06% Ti from the addition of 10% of an alloy containing about 11% Ti, showing that there was practically no loss. The following diagram (Fig. 1) shows the constancy and regularity of the increase in the transverse strength from the addition of about the same amount of alloy. The irregularities of the two curves of transverse loads before and after treatment may be derived from an imperfect incorporation of the alloy. The curve of tensile strengths follows closely those of the transverse strengths for good quality of pig metal down to the 20,000-lb. limit or thereabouts. Below this limit the improvement in tensile strengths seems to increase proportionately much more rapidly than in the transverse strengths. These curves, which were constructed from the average breaking loads of three bars of each kind of material, plainly show the improvement in the physical properties of the metal.

Experiments with Steel.—My experiments in this line have been limited to crucible steel, although others are in progress with open-hearth and Bessemer steel. These tests are much more difficult to make than with pig irons, as a difference of a few tenths of a per cent. carbon in the composition of pig iron does not very materially affect its properties, and from the analyses given above there is practically no change in the composition of the pig metal before and after treatment.

With steel it is very different, as a difference of 0·2 or 0·3% C may change a mild steel to a hard steel with widely different properties. In crucibles it is difficult to get a steel below 0·25% C, and consequently the experiments have been limited to steels containing some 0·4% C, especially to tool steels and others of even higher carbon content. The alloys used were reduced by aluminum and contained about 25 to 30% Ti. They were free from carbon (see analysis, page 723); they were introduced in the powdered state, after the melting of the steel or with the cold steel of a charge. It would have been much preferable to introduce them in the molten metal by means of the closed iron pipe, and to use alloys lower in titanium, like for cast iron. As a consequence, as it happens with the addition of other ferro compounds, but in a much greater proportion, there was a loss of titanium.

Since these small quantities were beneficial, the question arises, Does not the titanium of the alloy act as a purifier to eliminate from the steel certain constituents, some of which may be possibly gaseous, in a manner similar to the action of ferromanganese, which removes the oxygen from the metal after the other impurities have been removed by oxidation in the Bessemer converter?

Wm. Metcalf, in his work on steel,* states that titanium may remove from steel the nitrogen, the presence of which in steel, according to Percy and other

* *Steel: A Manual for Steel Users*, by Wm. Metcalf. 1897.

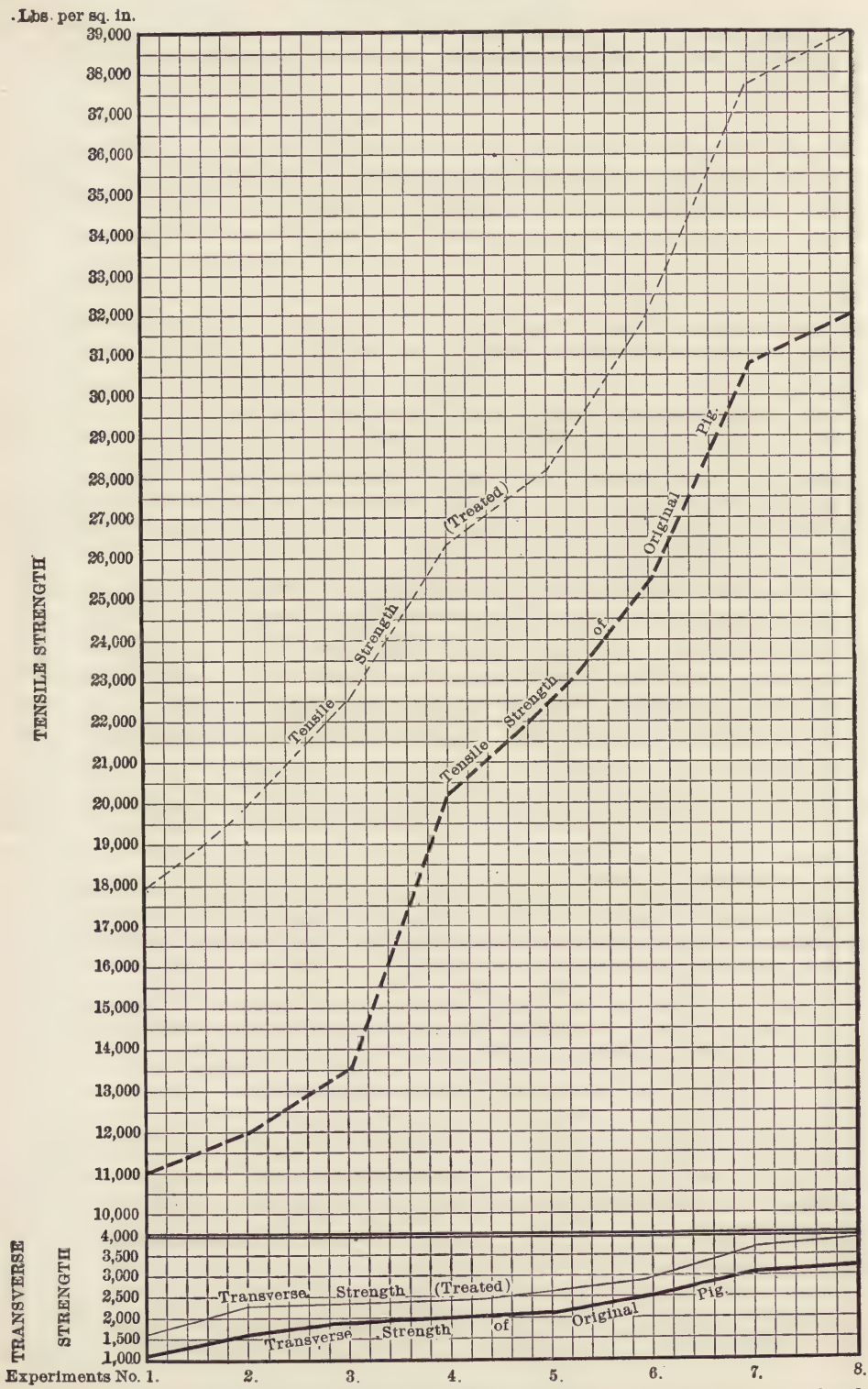


FIG. 1.—Diagram showing the Increased Strength imparted to Pig irons of different qualities by the addition of 4% of Alloy containing from 10 to 15% Ti. Average of three bars for each experiment.

eminent authorities, is so prejudicial to the strength. If so, the beneficial effect of the use of the titanium alloy even if but little titanium remained in the metal, would find its explanation, and its use in the open-hearth and Bessemer steel processes well indicated. From experiments and analyses by Prof. John W. Langley of crucible, open-hearth and Bessemer steel containing equal amounts of manganese, silicon, carbon, sulphur and phosphorus,* the crucible steel proved of best quality, next the open-hearth and finally the Bessemer. Furthermore, the quantities of nitrogen contained in these three kinds of steel diminished from the crucible to the Bessemer, which is readily explained by the method of manufacture in each case. However, be all this as it may, my experiments with crucible steel tend to show that the presence of titanium, either in small or more important amounts, imparts to the metal a greater ductility, a fact which was particularly noticeable in the harder steels. Possibly in addition to the specific purifying action of titanium above alluded to, its presence in decidedly important percentages in some of the steels treated has secured *per se* certain of the qualities observed. Careful experiment alone can settle this question and a series of tests are now contemplated or being carried out on steels with different increasing percentages of titanium for the same percentage of carbon.

Tests of tools manufactured from this treated steel, cutting tools, chisels, crowbars and hammers showed remarkably good results.

In order to judge of the effect of the addition of the titanium alloy, the physical properties should be compared with those obtained from other steels of similar composition not treated. Herein lies the difficulty, as the metal after treatment does not necessarily contain the same amount of carbon and possibly silicon as in the original state, not any more than two steels yielded by similar charges will, when operating in a crucible. The following table contains a comparison of physical tests of steel made by R. A. Hadfield† and F. L. Sperry, and chosen as presenting nearly the same composition as the steel treated by us with those made from metal that had been treated by the addition of titanium alloy. The test pieces in the latter case were 0·505 in diameter and 2 in. long between the clutching ends, which were threaded in accordance with the regulations of the United States Government tests. The test pieces were taken from ingots of the composition given in the table in each case. I offer the steels obtained by other parties having practically the same composition as mine (excepting the titanium) as the best terms of comparison available for the present. The results of the following physical tests show at least in which direction the influence of titanium can be looked for.

Considering these results the peculiar influence of titanium seems to be to increase considerably the limit of elasticity, elongation and contraction of area in the higher carbon steels, to an extent in some cases equal to that of certain nickel steels and of mild or even soft steels. Nevertheless, tempered tools made from the metal higher in carbon proved particularly well adapted for the uses to which this class of steel is applied.

* *Steel: A Manual for Steel Users*, by Wm. Metcalf. 1897.

† R. A. Hadfield, "Aluminum Steel," *Transactions of the American Institute of Mining Engineers*, XIX., p. 1041; F L. Sperry, "Nickel and Nickel Steels," *Ibid.*, XXIV., p. 51.

TESTS OF CRUCIBLE STEEL.

	Composition.							Physical Properties.			
	C.	Si.	Al.	S.	P.	Ni.	Ti.	Elastic Limit.	Ultimate Strength.	Contraction of Area.	Elongation.
	%	%	%	%	%	%	%			%	%
Hadfield	0·49	0·23	0·31					30,441	73,248	(a)22·28	18·50
Hadfield	0·48	0·33	0·11					32,032	66,304	10·00	9·00
Rossi	0·479	0·29	0·30				0·69	35.000	81,250	38·80	24·40
Sperry	0·51					3·93	0·69	35.000	81,250	27·10	16·00
Hadfield	0·65	0·23	0·18	0·036	0·054			32,211	58,912	4·40	3·50
Hadfield									58,912	(a)9·50	(a)9·00
Webster	0·69	0·39		0·037	0·060					12·20	9·50
Rossi	0·68	0·30	0·20	0·042	0·059		0·079	41,000	103.000	17·40	26·80
Hadfield	0·85	0·40	0·29					35.549	91,100	4·40	4·50
Rossi	0·815	0·42	0·32				0·090	66,500	122,500	16·60	11·10
Rossi	0·854	0·37	0·29				0·120	76,500	141,500	14·60	8·40
Rossi	0·826	0·40	0·31				0·095	70,000	127,500	21·90	8·40
Rossi	0·849	0·37	0·09				0·100	74,000	130,000	20·82	8·90
Sperry	0·96					3·10		Not given	151,880	12·90	8.00
	0·91					3·10		Not given	138,000	(a)22·30	9·88
Rossi	1·22						0·12	59,250		30·90	10·00
Rossi	2·165						1·00 0·10	65,000	Defective	10·50	8·75

(a) Annealed.

OTHER ALLOYS OF TITANIUM.—The method of aluminum reduction outlined above, is capable of generalization and may be used to obtain any metal, ferro metal or alloys of any two or more metals. In the case of ferro metal, it is only necessary to add the proper amount of scrap iron to the bath of aluminum, and to charge in the furnace the oxides of the metal or metals to be reduced. In this way ferromolybdenum, ferrochrome, or a ferrochrome-molybdenum may be obtained. Furthermore, if the oxides of the metal or metals occur associated with iron oxides, as in chromite for instance, by the method of concentration and addition of proper fluxes, most of the iron may be removed from the chromic oxide, affording a good by-product of charcoal iron, at the same time the chromic acid will be concentrated in a slag which, treated by aluminum, will produce a ferrochrome (or other metal) at a cost several times below that at which the results would be secured by the use of aluminum in powder.

If an alloy be desired of two or more metals, other than iron, for instance, copper and titanium, it is only necessary to replace the scrap iron by scrap copper, charging it with aluminum in the furnace and melting both. Add the oxide of the metal intended to be associated with copper, if available sufficiently pure and cheap, or better, if this oxide is found associated with iron oxide, a concentrate of the same from which the iron has been practically eliminated by the method described. Following this line of thought alloys of copper and titanium were easily made that contained 5, 8, 10 and 15% Ti; the last of sufficient hardness to scratch glass easily.

When added to manganes bronze in a manner similar to the treatment with ferrotitanium in the proportion of about 4% of the alloy, the cupro titanium thus obtained gave the following results as recorded in the testing laboratory of a large construction works. The tests were made on a round bar: Diameter, 0·798 in.; area, 0·5 sq. in.; breaking load, 31,540 lb.; tensile strength per sq. in., 63,080 lb.; limit of elasticity per sq. in., 25,200 lb.; elongation in 2 in., 0·9 in.; elongation, percentage of original length, 45; reduction of area, 41·56%. These results were considered exceptional for material of this kind.

REVIEW OF THE LITERATURE ON ORE DRESSING IN 1900.*

By Robert H. Richards.

Breakers and Fine Crushers.

Crushing Machinery.—Two new breakers have appeared: The *Austin breaker*,† which is of the gyratory (Gates) type, and the *Gouverneur rock breaker*,‡ which is really a grinding machine of the cone or coffee-mill type. The latter is used for crushing talc in New York State, taking stuff that has been through a breaker set at 2 in. and grinding it down to 0·125-in. size and finer at the rate of from 3 to 5 tons per hour.

An enormous Gates breaker has been constructed to crush hard Minnesota iron ore. It weighs 75 tons, has three receiving openings each 20×48 in., and crushes 150 tons per hour down to 4-in. cubes.

The Sturtevant centrifugal rolls§ are crushing rolls of a new design which substitute the centrifugal force due to weights, for the pressure of springs commonly employed on rolls. The roll consists of a roll shell encircling a shaft. The former is lined up and prevented from endwise motion by two large flanges held to the shaft by a conical fit and nuts. It is centered by the action of sector weight blocks guided for a short travel radially toward and from the shaft. At the outer end of their journey, they are stopped and lined up by rims on the above mentioned flanges. The inside diameter of the rims is 0·0625 in. larger than the inside diameter of the roll shell. If a steel pick point comes while the rolls are crushing rock it simply pushes back the shell and the weights until it has passed. When the rolls are to be run at slow speed, interior springs are inserted to hold the weights out. The claim made is that the crushing is done with less strain to the machine than with ordinary rolls.

The American steam stamp‖ is a small machine belonging to the same class as the Tremain, the Wood and the Hammond, and designed for gold milling. The special features of it are that it has adjustments for varying the number of the strokes and also the height of the stroke. The mortar is also adjustable up and down to compensate for the wear of the shoe and die.

* The subject of gold milling is given under the caption, "Gold and Silver," elsewhere in this volume.

† *Engineering and Mining Journal*, Dec. 22, 1900.

‡ *Ibid.*, May 12, 1900.

§ *Mines and Minerals*, February, 1900.

‖ *Engineering and Mining Journal*, Dec. 15, 1900.

*A prospecting gravity stamp,** of small size, run by hand, has been put on the market by John Taylor & Co. In construction and principle, it is like a single California gravity stamp. The total weight of the falling part is 45 lb.

Screens.

The Pratt-Wethey screen† is a stationary vertical conical screen, large in diameter at the top, tapering to a point with a small opening at the bottom for the discharge of the oversize. The pulp is distributed by centrifugal force against the inside of the screen at the top by three revolving horizontal radial discharge pipes. Halfway down the screen the oversize is returned to the center by a diaphragm, to be again thrown out by three other smaller discharge pipes similar to those above.

Classifiers.

The Ayton intermittent thick pulp extractor‡ is designed to relieve pulp from much of its accompanying water, which is undesirable in subsequent operations. It may be described as a hopper-shaped unwatering box with a large spigot plug below, which is opened periodically by a mechanically driven cam movement and closed by a lever and spring. A box 10×10×8·5 ft. deep should deliver 8 to 10 tons of thick pulp in 24 hours. At the Bote mill, Zacatecas, Mexico, the pulp from the six Chili mills, which crush 70 to 75 tons of ore per day, contains 85 to 90% water. Of this pulp 78 to 87% is returned by the pulp extractors to the Chili mills as practically clear water, while the remaining 13 to 22% passes out of the spigot as a thickened pulp containing only about 40% water.

Hydraulic Centrifugal Separator.—L. Kleritj and O. Bilharz§ have given an elaborate mathematical discussion of the theory of separation by a hydraulic centrifugal separator, in which the ore is thrown out radially horizontally through either a vertically rising or vertically descending mantle of water. There is no mention of its use.

Jigs.

A New Screen for Jigs‖ has been devised by "Oberwaschmeister" Rompf at the Muhlenbach mine. It consists of strips of punched plate with the parallel edges bent at right angles so as to have an inverted U-form. The horizontal part is about 130 mm. wide and the vertical flanges are 35 mm. high. Several such plates are put in place with the flange of one fastened to the flange of the next. The flanges give the requisite stiffening so important for a jigging screen. Screens of this kind used in jigging galena and blende were in good condition after 20 weeks, while the wire screens which they replaced lasted but 6 to 8 weeks.

* *Engineering and Mining Journal*, March 3, 1900. † *Ibid.*, Dec. 22, 1900. ‡ *Ibid.*, April 14, 1900.

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, March 10, 17 and 24, 1900; *Colliery Guardian*, March 16, 1900.

‖ C. Blömeke, *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, March 17, 1900; *Colliery Guardian*, March 23, 1900.

New Developments in Jigging have been noted editorially* and attention called to the rapid speed and short stroke adopted by W. J. Evans in the Montana mills —180 strokes per minute of 1·5 in. length, on ore 1·5 in. in diameter. Mr. Evans holds that oft-repeated suction to assist gravity is what is needed for rapid jigging. He used a thick jig bed and coarse jig sieves.

Fine Concentrators.

Riffle Tables still continue to broaden their field. At Lake Superior, Wilfley tables have replaced the fine Collom jigs and the revolving convex slime tables in some of the mills treating native copper rock.

The Wilfley tables are able to work up the old zinkiferous tailings dumps at Leadville, Colo. Two mills, one a stamp mill and one a roll mill, each of a capacity of 30 tons, equipped with Wilfley tables, treated this stuff containing 30 to 35% Zn, 8 to 14% Pb and 4 to 6 oz. Ag per ton, and made two valuable products: (1) silver lead and iron, which is desired by the smelters as a flux; (2) the zinc ore (blende) which amounted to 7,500 tons in six months and was shipped to zinc works in the East or abroad.†

The Bartlett table is now made with a solid iron top made in one piece. A Bartlett table tried at Clausthal, Germany, gave unsatisfactory results.‡

The Hallett table, made by the Gates Iron Works, has its lead surface replaced by a linoleum top.

The Wilfley table in Canadian mills§ has been discussed editorially, and its use commended as a great advance in concentration of gold ores, but the mode of mounting the table is criticised in two ways: first, the re-treating of middlings upon the same table under the assumption that this pulp is of the same quality as the feed, which it is not, and therefore should be treated by itself; and secondly, the failure to use a classifier to prepare the pulp for the Wilfley table by removing the fine slimes. The article also commends the modification whereby the heads are discharged from the end instead of from the side.

End bump tables are in use at the new tailings plant at Kellogg, Idaho,‖ each 8 ft. long, 39 in. wide. They are driven by a cam to give the quick bump and a spring for the slow return. The metal or wooden surface of the table is covered with wire netting or, if very fine stuff is treated, with cloth. The jerking motion discharges heads at the upper end, and the tailings are carried to the lower end by the current of water. Pulp is fed on top of the screen; wash water is fed between the screen and the top of the table. It is said to wash ores of different sizes ranging from 2 to 80 mesh, but the stuff should be closely sized or classified.

Description of Mills.

Two Missouri zinc mills have been described.¶ They do not differ much from

* *Canadian Mining Review*, Sept. 30, 1900.
† Thomas Tonge, *Engineering Magazine*, September, 1900.
‡ *Zeitschrift für das Berg-, Hütten- und Salinenwesen*, Vol. XLVIII., 1900, p. 141.
§ *Canadian Mining Review*, March 31 and Sept. 30, 1900.
‖ *Mining and Scientific Press*, Nov. 3, 1900.
¶ *Engineering and Mining Journal*, June 2, 1900; and H. A. Titcomb, *Ibid.*, July 28, 1900.

the general scheme of that region given in THE MINERAL INDUSTRY, Vol. VI., 1898, p. 699.

The Standard Mine mill has been especially dwelt upon in Arthur Lakes'* review of the concentrating work in the Cœur d'Alêne region. Here as in the general type of mills for concentrating the ores of this region containing argentiferous galena, pyrite and blende, the ore is crushed by breakers and rolls, sized and classified by trommels and hydraulic classifiers, and separated by jigs, slime tables, vanners and Wilfley tables. Middlings are recrushed—the coarse by rolls, the fine by Huntington mills—and finally separated by jigs and Wilfley tables. For the saving of the fine slimes, a canvas plant has been installed consisting of 52 canvas tables and a Wilfley table to clean up the concentrates of the canvas tables.† The mill treats 300 to 400 tons per 24 hours and is run by water power.

The new Bunker Hill and Sullivan mill‡ in the Cœur d'Alêne region, Idaho, with a capacity of 1,000 tons in 24 hours, was put up in four months on the site of the old mill, which was destroyed in April, 1899. The plant is built in two independent sections and comprises: 8 pairs rolls, 4 five-foot Huntington mills, 44 jigs, 8 three-deck circular slime tables, 21 Frue vanners, 8 elevators, 2 four-foot Pelton wheels, besides trommels and classifiers. The general scheme is much the same as that of the old mill and does not differ essentially from that of the Standard Mine mill, described above, except that it has no canvas plant.

Two Mill Plans for Small Mines, 40 and 20 tons per 24 hours, respectively, have been described by S. I. Hallett.§ These are laid out on the basis of the greatest simplicity combined with least running expense. His outline for 40 tons is as follows: Breaker, bin, feeder, No. 1 classifier, the coarse product from which goes to Chili mill and thence to No. 2 classifier which yields two spigot products treated on two Hallett riffle tables and an overflow which goes to spitzkasten. The fine product or overflow of No. 1 classifier goes to spitzkasten direct. The first spigot of the spitzkasten goes to a third Hallett table and the second, third and fourth spigots go together to a fourth Hallett table; the overflow is waste.

The Ray Copper Mines.‖—According to Alexander Hill the ore carries carbonates and oxides of copper in diorite, assaying from 3 to 6% Cu, and in the small experimental mill yielded concentrates assaying 30% Cu. A new mill has recently been erected.

The ore which has previously passed over a grizzly at the mine and had the oversize crushed in a Gates breaker, comes to the mill in railway cars and is

* *Mines and Minerals*, February, 1900.

† Although canvas plants have been used considerably for the saving of fine concentrates in gold stamp mills, this is the first case that has come to my notice of their use at the end of a coarse crushing concentrating mill. I believe it is a step in the right direction. Very recently I have been informed that the Revenue Tunnel mill at Ouray, Colo., has put in canvas tables to treat fine slimes left in the ore after it has passed over the Wilfley tables, and they have proved a very profitable investment. This is a graded crushing concentrating mill treating ore containing galena, pyrite, tetrahedrite and blende in a gangue of quartz and porphyry.—R. H. RICHARDS.

‡ *Mines and Minerals*, March, 1900.

§ *Mining and Scientific Press*, May 5, 1900.

‖ *Engineering and Mining Journal*, May 19, 1900.

dumped into bins. These deliver to a trommel with 1-in. holes, the oversize of which is recrushed by rolls while the undersize goes to a series of trommels with 0·75-, 0·5- and 0·25-in. holes followed by a Pratt-Wethey screen. The oversizes of all these are jigged on several two-compartment jigs which yield heads, which are concentrates, and middlings and tailings, which are recrushed in Bradley pulverizing mills and then go with the undersize of the Pratt-Wethey screen to Meinecke classifiers. The four-spigot products of these classifiers are treated on 12 Hallett tables and the overflow goes to a spitzkasten, the spigot products of which are treated on eight Hallett tables. In case the Hallett tables make any middlings, they are reground in a tube mill, classified and treated on other Hallett tables. The capacity of the mill is 250 tons per day. The mill is run by four 50-H.P. Weber distillate engines.

The Peck-Montana Mill at Corbin, Mont., using Peck centrifugal concentrators, has been described by G. W. Winter.* The arrangement of the machinery is as follows: A Comet breaker, size C, crushes the ore to 1·25 in. diameter and delivers it to one of the receiving bins. This breaker and the motor that drives it is mounted on trucks which enable it to be placed in position over any one of the bins. James feeders feed the ore to belt elevators and thence to eight sets of 10×30-in. rolls which crush to 4 mesh. Water is added to the ore and it passes through a sampler, thence to eight barrel pulverizers with balls, which reduce it to 20 mesh and finer at the rate of 15 to 30 tons per barrel per 24 hours. From here it goes to the first hydraulic classifiers yielding three products: 1st (10% of total), coarser than 20 mesh, goes back to barrel pulverizer; 2d (40% of total), 20 to 80 mesh, goes to the second hydraulic classifier and yields four sizes, which are concentrated on 2 four-deck round slime tables 18 ft. diameter; 3d (50% of total), 80 mesh and less, goes to agitators which serve to deliver the pulp in thoroughly liquid condition to Peck centrifugal concentrators. The tables and centrifugal machines yield heads and tailings. The tables also yield middlings which go back to the second hydraulic classifiers. The mill is run by electricity, generated by water power 12 miles distant. No capacities of the machine are given.

The new concentrating mill at Nacosari, Mexico, has been briefly described by H. B. Layton.†

At the Pewabic Iron Mine, Lake Superior,‡ the iron ore, which is contaminated with a sandstone gangue, is dressed as follows: A 1·5 in. grizzly yields oversize to a pan conveyor from which rich ore and waste are picked out, leaving the residue to go to a breaker and thence to a 0·75-in. grizzly. The oversize of this is crushed by a pair of 14×24-in. rolls set at 0·75 in. and goes to a trommel with three compartments with 0·1875-, 0·875- and 1·25-in. diameter holes. The three coarse products—over 1·25, 1·25 to 0·875 and 0·875 to 0·1875—all go to jigs while stuff below 0·1875 in. goes to hydraulic classifiers yielding spigot products to jigs and overflow to waste. The undersize of the 1·5-in. grizzly goes to a trommel with 1·25-in. holes yielding oversize to the 14×24-in. rolls mentioned above

* *Engineering and Mining Journal*, March 31, 1900. † *Ibid.*, June 16, 1900.

‡ L. M. Hardenburg, *Proceedings of the Lake Superior Mining Institute*, Vol. VI., 1900, p. 23; *Engineering and Mining Journal*, April 21, 1900.

and undersize to join the undersize of the 0·75-in. grizzly and thence to a two-compartment trommel with 0·1875- and 0·875-in. holes. This yields two sizes—over 0·875 and 0·875 to 0·1875—to jigs, and a size through 0·1875 in. to the hydraulic classifiers previously mentioned. There are 18 jigs, nine of which have three compartments each and treat stuff coarser than 0·1875 in., while nine have two compartments each and treat stuff below 0·1875 in. The jigs yield: (1) discharges which are concentrates, (2) tailings which are waste, (3) hutches. The hutches of the coarse jigs are treated on two finishing jigs; those of the fine jigs go to hydraulic classifiers which readily separate the ore from the sand. The mill uses 800 gal. of water per minute, treats 280 to 300 tons of raw ore per day, requiring three men and eight boys per shift. The engine is 65 H.P.

Frue Vanners in Cornwall.—R. Arthur Thomas* gives the results of the use of Frue vanners without previous classification upon tin stamp stuff from the Dolcoath mine, as compared with the old Cornish method of treatment by classifiers, buddles and frames (rectangular slime tables). The 60 gravity stamps and the two Husband pneumatic stamps (each equal to 10 gravity) crush the ore from 1·5-in. diameter through a copper screen punched with round holes equal to a 27-mesh wire screen at the rate of 125 long tons per day [24 (?) hours] sending the pulp to 27 six-foot Frue vanners with smooth belts, as corrugated belts were found to bring up too much coarse material into the concentrates. For rich ores they use four vanners for 10 stamps; for poor ores only three. The vanner heads carry 50% of black tin carrying 65% metallic tin, that is to say, the heads assay 32·5% metallic tin; they are calcined and further concentrated to get a marketable product. The tailings are classified, yielding coarse, which is concentrated (method not given) and pulverized, and fine, which is concentrated on Cornish frames (rectangular slime tables) and on buddles (revolving convex slime tables).

The old Cornish method produced concentrates for calcining, carrying 25% of black tin, costing 30c. per ton (1s. 3d.). The new method produces concentrates for calcining carrying 50% of black tin, costing 12c. per ton (0s. 6d.). Mr. Thomas thinks the loss in the tailings is less with the new than with the old method. Critics of this paper doubt the wisdom of omitting the preliminary classification. Further developments will be awaited with interest.

In tin dressing in the Malay peninsula† the method formerly used was essentially the Cornish one, *i.e.*, buddles, frames and kieves. It has been found advantageous, however, even though labor is very cheap, to replace these by Frue vanners with corrugated belts which receive the pulp direct from the stamps without classification. There are 60 stamps and 18 vanners. The ore yields an average of 3·5% tin oxide; the vanner heads run 25 to 45%; the tailings 0·13 to 0·22%. The heads go straight to the calciners, the tailings are waste. After calcining, the heads are pulverized by two pulverizers and further concentrated by two Frue vanners with plain belts yielding final heads carrying over 70% tin and tailings with not over 0·26% tin oxide. The mill treats about 2,500

* *Transactions of the Institute of Mining and Metallurgy*, Vol. VII., 1899, p. 175.
† W. H. Derrick, *Transactions of the Institute of Mining and Metallurgy*, Vol. VII., 1899, p. 12.

tons of ore per month; the amount calcined is about 250 tons per month; the finished concentrates amount to 85 to 95 tons per month. The average tailings of the mill contain 0·22 to 0·35% tin oxide. The total cost of dressing is $1·32 (5s. 6d.) per ton. The use of vanners has reduced the cost, as they make much cleaner heads than buddles and consequently a smaller amount (50% less) to go to the calciners, so that the roasting charges have been diminished. Jigs were tried here at one time, but did not give satisfactory results.

The Testing Works of Henry C. Wood in Denver has been described by Arthur Lakes.* This plant is located in a three-story building 40×100 ft. in size. It contains breaker, rolls, stamps, trommels, shaking screens, classifiers, jigs, Wilfley tables, canvas tables, cyanide vats, amalgamated plates, magnetic separator, and the necessary elevators, conveyors, feeders, samplers, bins, etc. The arrangement of these machines is more or less elastic, but testing is usually carried out along the following lines:

(1) Coarse crushing by breaker and rolls, sizing and classifying by trommels and hydraulic classifiers and separation by jigs for the coarse, and by Wilfley tables for the fine. The tailings are recrushed by rolls or stamps and run over amalgamated plates followed by Wilfley tables.

(2) Fine crushing by breaker and rolls, sizing by trommels and shaking screens, and separating on Wilfley tables. The tailings are recrushed by rolls and re-treated on Wilfley tables, the fine tailings of which go to canvas tables and then to cyanide vats if there are still some gold values left.

(3) Stamping with a five-stamp battery, each stamp of which weighs 800 lb. These are followed by amalgamated plates and Wilfley tables with or without hydraulic classification. If desirable, the tailings may be treated by cyanide.

(4) Crushing by breakers and rolls and magnetic separation by a Wetherill separator so arranged as to give a strong field for weakly magnetic minerals or *vice versa.*

Clay Washing in Ohio to remove limestone pebbles has been described by A. M. Fish.† He uses a circular vat with central shaft having horizontal arms to which are attached drags of scantling with long teeth. It requires 5 H.P. It is fed by clay from a dump cart with water. The liquefied clay is overflowing constantly through a screen, which for ordinary brick and tile is 4 mesh, and runs out into a large level settling pond 6 square rods in area made by removing 6 in. of soil and piling it in a ridge around the area. They wash only in the spring, charging up a pond; the clay dries and weathers for a year and is then used for tiles and bricks. The limestone pebbles are cleaned out of the bottom of the vat every year or two.

General Milling Considerations.

The history and development of the methods of concentrating ores has been reviewed by A. W. Warwick,‡ who has given rules for guidance in designing a mill.

* *Mines and Minerals*, October, 1900.

† *The Clay Worker*, Vol. XXXIII., 1900, p. 360.

‡ *Mining and Scientific Press*, Jan. 13 and March 10, 1900.

The importance of having constants determined to guide the mill engineer in designing mills, taking as an example the decision as to how many vanners should be employed, has been pointed out by F. T. Snyder.* As the number of vanners in the mill increases, the loss of values in the tailings diminishes, but on the other hand the first cost and running cost of the mill increases. The question then arises, At what point will the added cost of more vanners offset the added gain in values saved? The problem is complicated by the varying richness, fineness and specific gravity of the ore.

"Tendencies in Concentration,"† has been noted editorially; the article commends the wider use of jigs which has been brought about in modern times by the use of graded crushing and concentration, taking out the ore in coarser sizes, and thereby saving the making of excessive quantities of fine slimes by fine crushing only to be lost in the water. Since the riffle tables have come in, however, these should relieve the jigs from the treatment of the finest jigging sizes. The increased use of canvas tables and similar devices for treating the finest slimes is also advocated.

The Development and the Present Condition of Sardinian Ore Dressing has been ably discussed in the valuable paper of N. Pallati‡ read before the Mining Congress at the Paris Exposition. He takes up the machines individually as follows:

Trommels and ordinary shaking screens have almost entirely been supplanted by *Ferraris swinging screens.*§ This is a long narrow horizontal screen which vibrates in an obliquely upward direction, and, in doing so, conveys the sand forward at a rapid rate. The motion is obtained by an eccentric joined to one end of the screen by a horizontal connecting rod vibrating 350 to 360 times per minute with a throw of 25 to 30 mm. The peculiar conveying motion is due to the use of supporting rods beneath the screen frame which are inclined about 70° with the horizontal, causing the screen to be raised and lowered at the same time that it is moved forward and backward. The coarse screen is 600 mm. wide, 4 m. long; half the length has 14-mm., and the other two quarters have 20- and 30-mm. holes. The medium screen is the same except that the holes are 5, 7 and 10 mm. diameter. This group of screens has the great capacity of 10 cu. m. per hour.

Luigi Sanna, at Malfidano, has solved the use of this principle for fine screening. He uses screens 600 mm. wide; the first part is 1,200 mm. long, the second, 800 mm. He places his sieve over a pointed box in such a position that on the downward movement the sieve just touches the water sufficiently to free the holes. The water is maintained at an exact level by feed water and overflow which enables discharge spigots to be running all the time. Ferraris has used this to complete his sieve series with 1·9- and 3-m. holes. Sanna claims that he can screen by this method down to 0·5 mm. in size.

* *Journal of the Canadian Mining Institute*, Vol. III., 1900, p. 102; *Mining and Scientific Press*, July 14, 1900.

† *Canadian Mining Review*, Dec. 31, 1900.

‡ *Colliery Guardian*, Oct. 12, 1900; *Bulletin de la Société l'Industrie Minérale*, Series III., Vol. XIV., 1900, p. 1263.

§ See also, E. Ferraris, *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, May 5, 1900.

This system saves space, height of mill and power, and has little wear. It uses less power than a trommel and does twice the work. In mounting his series, Ferraris saved the height of a whole floor (3 m.) in mill construction. He used his medium size a year without replacing a single screen plate. The appartus is not patented.

The Ferraris hydraulic classifier treats the undersize of the fine screen. It is a bent pipe of about 5 in. diameter which at the feed has a slope of about 30° gradually diminishing until it becomes horizontal at a distance of about 10 ft. beyond and 3 ft. below the beginning. In the horizontal part of the pipe and on the underside is put a pocket with hydraulic water and spigot discharge for the heavier grains. The pocket has a tubular form with circular section and with height about five times the diameter. The tube flares at the bottom and the hydraulic water is admitted through an annular opening all around the circle. The small opening for discharging the spigot product is at the center at the bottom.

Jigs treat coarser sizes from the screens and classifiers. Simple eccentric jigs are preferred with adjustable plunger throw.

Shaking tables with an oscillating-conveying-motion precisely similar to that employed on the Ferraris swinging screens are used. The table is from 8 to 10 ft. long, 4 ft. wide, slightly inclined transversely and is fed on the high side at the rear end. The jerking motion conveys the sand forward while the wash water, passing across the table, carries the sands down toward the lower side. The minerals of different specific gravity each move in their own diagonal lines and can be separated from each other where they report at different points on the lower edge. It treats a half a ton of dry material per hour.

A Model Plant at the Paris Exposition was constructed by M. H. Lenicque,* of Paris, and embodied the results of his experience in ore dressing. The plant consisted of the following: His ore breaker is of special sectional pattern and has a safety device to provide for excessive strains. One size weighs 4·7 tons and crushes from 40 to 50 tons to 2 in. diameter in 12 hours. On his rolls he uses four wrought-iron longitudinal pieces instead of the cast-iron bed-plate, hardened cast-steel shells, and helical steel springs to take up the shocks. These rolls, weighing 3·79 tons, crush the breaker product to 0·3125 in. at the rate of from 28 to 35 tons in 12 hours, consuming from 6 to 8 H.P. When coarse and fine rolls are used the worn shells from the fine rolls are transferred to the coarse, effecting a great saving thereby. An automatic distributor is used to distribute the ore over the whole length of the roll.

In his "Jaw action breaker," the movable jaw is pivoted at a point on a level with the toggles and the usual jaw toggle is replaced by an arm rigidly cast upon the moving jaw. The effect produced is an approaching and receding motion at the mouth and an up and down, or torsional action at the throat of the machine, making a small proportion of fine dust. With jaws 12 in. wide, it crushes only from 5 to 8 tons in 12 hours from 2 in. down to 0·3125 in., but it has a first cost and running cost much less than that of rolls.

Wash trommels and sizing trommels are all made conical and are direct belt

* *Colliery Guardian*, Aug. 10, 1900.

driven. The wash trommels are of unperforated iron plate lined by staves of hard wood kept in place by iron hoops. Where the material is very difficult to clean, angle irons arranged helically are put in, or pieces of chain. If its work is not too hard, it is often combined with a screening part. For sizing trommels, he prefers round perforated plate to wire cloth: (1) because the diameter of a round hole is equal in all directions, which is not the case with square holes in wire cloth, (2) because he finds round holes are less liable to clog, and (3) because the plates cause less abrasion on friable ores than wire cloth. He uses mild steel plate for all sizes down to 1-mm. diameter holes.

For hydraulic classifiers, he uses a series of cast-iron pointed boxes up to six, the later boxes larger than the earlier, with hydraulic water brought down inside by vertical central pipes with cup shaped ends. The three larger sizes, namely, 1 mm., 0·75 mm. and 0·5 mm. approximately, go direct to three jigs; the finer sizes to the slime tables.

Jigs are made of cast iron to prevent them from getting out of shape. They are of two, three, four and five compartments each. He recommends sliding block accelerated plunger motion for the 2-sieve jigs and simple eccentrics for those with more than two compartments. With his jigs he is able to treat sands down to 0·5 mm. in size.

For slime tables he recommends convex conical tables with wrought-iron frames coated with plate iron and upon that a rubber surface.

Magnetic Concentration.

An Elaborate Paper on Magnetic Concentration was read by Dr. Hermann Wedding before the International Congress of Mines and Metallurgy.* He described over 20 forms of separators and gave an account of the work they are doing, if any. Below are given his descriptions of three of the machines which are of recent date. The first two are adapted to the separation of strongly magnetic minerals, the third to that of weakly magnetic minerals.

The Dellvik-Gröndal separator is used for finely disseminated ores and especially to treat slimes. As shown in Fig. 1 there is a drum *AB* of cast iron and consisting of a series of rings. In the spaces between the rings are placed coils of copper wire carrying the electric current. The drum is rotated by means of the bevel gearing. *CC* is a solid drum of wood, studded with steel pegs revolving three times faster than *AB* but in an opposite direction. Pulp is fed through the launder *N*, terminating in the circular launders, *QQQQQ*, which enclose the drum *AB* for about one-third of the circumference, thereby offering larger area for the pulp to be acted upon. Further water is supplied by the pipe *L*. The magnetic particles thus brought under magnetic influence attach themselves to the rings on *AB* and are carried around as *AB* revolves. The particles which escape the first ring are caught lower down and so on, each succeeding ring being more strongly magnetic than the one above. The non-magnetic particles being unattracted are washed down into the launder *P* together with the excess of water. As each peg of the drum *CC* is successively presented

* *Bulletin de la Société de l'Industrie Minérale*, Series III., Vol. XIV., 1900, p. 1197.

to the rings of the drum *AB*, magnetism is induced therein and the magnetite hops over and forms in tufts on each peg. The revolution of the drum *CC* carries these particles out of the magnetic field when the most of them drop off and the remainder are washed off by a strong jet of water from the pipe shown at *K*.

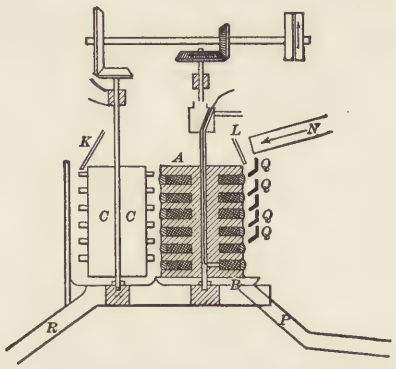


FIG. 1.—THE DELLVIK-GRÖNDAL MAGNETIC SEPARATOR.

This separator has been used at Pitkaranta in Russian Finland since 1894 for concentrating lean iron ores.

The form of Heberli separator used for roasted iron ores or complex magnetite ores has the material brought to it by a stream of water in the launder *A* (see Fig. 2). An endless rubber belt passing over two end rollers serves to lead such

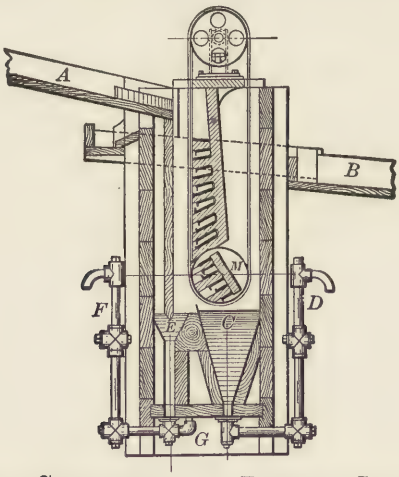


FIG. 2.—THE HEBERLI SEPARATOR FOR ROASTED IRON ORES OR COMPLEX MAGNETITE ORES.

magnetic particles as are attracted to the magnets down into the hopper *C* whence they pass out through *D*. The non-magnetic particles fall into *E* and pass out at *F*. The magnets are surrounded by a water-tight iron casing and the whole machine is put in a wooden tank filled with water to above the level of the upper magnet. Ordinarily, three machines are run in series.

A Mechernich separator consists of two cylinders with parallel axes, each cylin-

der wound at its middle in such a way that the two cylinders are two magnets with poles of opposite polarity lying adjacent to one another. The cylinders revolve in opposite directions on axes usually horizontal but sometimes inclined or even vertical. The axes lie in a plane which makes an angle of about 20° with the vertical. The lower cylinder has a non-magnetic covering, the upper is bare iron. Material is fed between the two cylinders; the non-magnetic particles slip down around the lower cylinder; the magnetic particles attach themselves to the upper cylinder and are carried around by its revolution until they are outside the magnetic field, when they drop off into the heads and middlings bins. A machine with poles 10 in. wide will treat from 5 to 8 tons in 10 hours, while one with 12-in. poles will treat 10 tons. This machine requires finer material than the Wetherill, but it avoids the use of belts.

Dr. Wedding reports that a large number of minerals which are difficult to separate magnetically when dry are easily separated when they are put in suspension in water. He suggests a process of "magnetic washing" in which the difference in magnetic attraction will replace the difference in specific gravity used in ordinary washing of ores.

Wetherill's patent for separating weakly magnetic substances from non-magnetic has been sustained in Germany in a suit against the Mechernich separator.*

Wetherill Plants.—Mr. H. Smits† presented a paper at the Mining Congress at Paris on the magnetic concentration of ores in which he gave a short description of five different types of the Wetherill magnetic separator and outlined the plant at Franklin, N. J., the plant for tailings at Broken Hill, Australia, and the Lohmannsfeld plant. The last is the first installation to be made in Europe and is described more in detail. In it the ore contains galena, blende and spathic iron carrying as much as 12% Mn, with quartz and quartzite. The blende and spathic iron were obtained together as a middle-weight product of the jigs with zinc 15 to 22% and the rest spathic iron with 2·5% of gangue. As the company was unable to put up a roasting furnace to change the spathic iron to magnetic oxide, the alternative of selling the mixed ores for 12 to 15 marks ($2·86 to $3·57) per ton was formerly adopted. Experiment showed that the Wetherill magnetic machine, acting on 3-mm. grains of the jig product, made a zinc product carrying from 42 to 46% Zn and a spathic iron product carrying only from 1 to 3% Zn. Accordingly a plant was put up, the outline of which is as follows: The material treated is middlings from the jigs ranging from 1 to 10 mm. in size and containing from 5 to 20% moisture. It passes through two driers to a 3-mm. trommel. The trommel oversize goes to rolls crushing to 3 mm. and is then elevated back to the same trommel. The trommel undersize is elevated and conveyed past an ordinary electromagnet (to remove bits of iron, steel or magnetic oxide) to a set of trommels having holes 0·75-, 1·4- and 2-mm. in size. These trommels yield four products which are treated on three double Wetherill magnetic separators yielding three products: (*a*) spathic iron, (*b*) mixed spathic iron and blende, (*c*) blende. With five men and three boys, the plant treats from 3 to 3·5 tons of raw material per hour.

* *Engineering and Mining Journal*, Nov. 17, 1900.

† *Bulletin de la Société de l'Industrie Minérale*, Series III., Vol. XIV., 1900, p. 1243; *Colliery Guardian*, July 27 and Dec. 14, 1900; *Stahl und Eisen*, Dec. 1, 1900; *Engineering and Mining Journal*, Oct. 20, 1900.

The cost is 1·4 marks ($0·33) per ton of raw ore, to which add 2·5 marks ($0·60) for interest and depreciation, making a total of 3·9 marks ($0·93), but the products obtained sell for 32 to 35 marks ($7·62 to $8·33) per ton, making an added profit of 16 marks ($3·81) per ton, and there are 600 to 750 tons treated per month.

Pneumatic Concentration.

The Cammett Table.—It is reported that successful results have been obtained from the dry concentration of wolframite ore on a *Cammett table.**

The Hooper pneumatic jig, which is the old Paddock jig improved and which has been doing good work on graphite and garnet ores for several years, is now being put forward for general concentration. It is claimed to be doing good work on North Carolina gold ores and Missouri zinc ores.

The air separator† made by Pfeifer Bros. has two rapidly revolving horizontal iron plates, mounted one below the other on a vertical shaft. The upper one is solid, the lower is annular and is of greater diameter than the upper. Each is surrounded at a little distance outside its circumference by a nearly vertical iron mantle. The whole machine is enclosed in an iron casing which is cylindrical above and conical below. Material is fed upon the upper plate and is thrown outward by centrifugal force against the surrounding mantle, thence falls upon the second plate through an ascending current of air (produced by fan blades mounted on the shaft) which lifts out the lighter grains. The same thing is repeated with the heavy grains which fall upon the second plate The separated light and heavy stuff are collected separately in hoppers below and are drawn off periodically. A machine 2,100 mm. (82·7 in.) in diameter treats 2,000 kg. (4,400 lb.) of finely ground cement per hour.

Oil Concentration.‡

The Elmore Process.—A paper read by C. M. Rolker before the Institution of Mining and Metallurgy, April 25, 1900,§ describes the Elmore process, which consists of adding mineral oil to ore whereby the values (sulphurets) are floated and skimmed off.

At Dolgelly, Wales, 43 tons of the ore of the Glasdir mine have been tested by this process and the method is to feed the ore to a Comet breaker, then to a jaw breaker. It is then crushed wet in rolls and finally crushed fine in a Huntington mill with No. 6 needle screen. From this the ore and water are fed into one end of a horizontal mixing drum with annular helical ribs and between them lifting blades. In this the oil is added and incorporated, the helical rib then conveys the mixture out of the other end of the drum to the subsidence vessel. One ton of ore requires 1 ton of oil and 5 tons of water. The concentrates float to the top and the waste sand is drawn off from beneath. The concentrates are then put into a centrifugal drier or extractor and the oil recovered. Two gallons of oil per ton of raw ore are lost. The temperature used was between 54 and 57°F.,

* *Engineering and Mining Journal*, Oct. 20, 1900. † *Thon-Ind. Zeit.*, Vol. XXIV., 1900, p. 1920.

‡ This important subject has also been treated by Walter McDermott in his article on "Notes on the Concentration of Finely Crushed Ore," on pages 773–778 of this volume.

§ Abstracted in *Engineering and Mining Journal*, June 23, 1900.

and if the viscosity needed to be increased, a little mineral butter (heavier mineral oil) was used, but if it needed to be decreased, a lighter mineral oil was added.

At the Glasdir mine, the ore tested contained 1·12% Cu, 0·049 oz. gold and 0·8 oz. silver per ton of 2,240 lb. Of these 70% of the copper, 69% of the gold and 65% of the silver were saved when 14 tons crude ore were concentrated into 1 ton. The loss of 2 gal. oil, perhaps 30c. per ton, is a serious expense for the process to bear.

Coal Washing.

*The Langerfield Coal Separator** is a device for screening and picking coal automatically for which great claims are made. Description is withheld pending the granting of patents.

The screening and cleaning of coal and colliery surface arrangements, mainly in South Wales, have been discussed by S. A. Everett.†

At the Cadeby Colliery‡ near Doncaster, England, is a washing plant designed for the treatment of 100 tons of coal per day of 10 hours. The class of coal treated is a mixture of hard and soft coal with a high percentage of shaly fines.

The coal to be washed is screenings which have passed through screens with holes 1·75 in. in diameter. It is first elevated to a Humboldt sizing screen, consisting of three cylindrical screens mounted one inside the other concentrically. "The annular spaces between each successive pair are furnished each with a spiral trough running the whole length of the screen, which in one revolution intercepts and deflects the collected material and completely ejects and delivers the same to the receiving chutes. Before entering the screen proper, the coal is fed into a drum of unperforated sheet iron also provided with a spiral trough." The great advantage is that at each revolution, the whole of the coal received is emptied out and the incoming coal is received on screens free of material. In this way excessive attrition is avoided. Four sizes are made, namely 1·75 in. diameter to 1 in., 1 to 0·625, 0·625 to 0·375 and below 0·375. That below 0·375 in. goes by scraper conveyor to a second revolving screen with 0·15625-in. holes, the undersize of which is used for firing the boilers of the plant. The four sized products are treated each by itself on accelerated jigs which make three products: clean coal, shale and hutch product. The shale from the two sizes above 0·625 in. goes straight to waste; that from the two sizes below 0·625 in. together with all the hutch products is conveyed and elevated to a trommel which divides it into two sizes to be treated on jigs called re-washers. These yield clean coal and shale. The clean coal from the first four sizes (above 0·375 in.), called nut coal, is drained, washed with a stream of fresh water and screened into two commercial sizes for market. All the other clean coal (below 0·375 in.) goes to an elevator with perforated buckets which, traveling slowly, drains the coal and then delivers it to Humboldt disintegrators and thence to storage hoppers for market. The fine sludge which is left by the elevator is caught in settling tanks and after draining is used for firing the boilers. All water which is drained from the coarse coal and which overflows the settling tanks is used over again.

* *Mines and Minerals*, March, 1900. † *Canadian Mining Review*, Nov. 30, 1900.
‡ *Colliery Guardian*, March 23, 1900.

THE CONCENTRATION OF THE BROKEN HILL (N. S. W.) SULPHIDE ORES.

By T. J. Greenway.

General Considerations.—The Broken Hill ore deposits occur as a series of bodies of a considerable size, often more than 100 ft. in width, which collectively form a metalliferous belt, from 50 to 300 ft. wide, about 3 miles long, and extending to a depth which is as yet undetermined. The containing rock is micaceous schist, the banding of which exhibits much anticlinal and synclinal folding. The ore bodies lie more or less conformably with this banding, and frequently present many of the characteristics of fissure veins and "saddle back" formations, but the general appearance of the ore met with in the deeper workings would lead one to regard the ore bodies as metastomatic replacement deposits. The ore occurring above an average depth of 200 to 250 ft. is chiefly argentiferous lead carbonate and other oxidized ore. Immediately underneath the oxidized ore, a quantity of what is locally known as "friable sulphides" is met with; and underlying this is the compact sulphide ore. The friable sulphides and the oxidized ore have evidently been derived from similar ore. The oxidized ore, which seven years ago formed practically the sole product of the Broken Hill mining operations, is now nearly worked out, the present output being between 2,000 and 3,000 tons weekly; while the output of the sulphide ore is about 28,000 tons weekly, 20 to 30% of this being friable ore. The chief constituent minerals of the sulphide ore are galena, blende, garnet, modonite, quartz and feldspar, the garnet being more especially a constituent of the friable ore. These minerals are very intimately associated with each other, considerable proportions of both the galena and the blende occurring as mere films and specks in joints and in fracture and cleavage planes. The average sulphide ore produced contains lead from 14 to 20%, zinc from 10 to 20%, and silver from 6 to 16 oz. per ton. The whole of it is concentrated locally with the view of producing the largest possible proportions of argentiferous galena concentrates, which are either smelted at the Coast or exported to Europe where they command a ready sale. Various attempts have been made to produce marketable blende concentrates but so far they have been successful only under certain favorable conditions, consequently huge dumps of zinkiferous products have been accumulated awaiting the advent of some profitable method of treatment. The following figures show the quantity of lead, zinc and silver contained in the products now being thus dumped for future treatment at some of the chief Broken Hill mines:

	Lead.	Zinc.	Silver.		Lead.	Zinc.	Silver.
	%	%	Oz. per ton.		%	%	Oz. per ton.
A	4·9	9·3	5·3	F	7·0	14·5	7·5
B	6·1	13·3	6·0	G	6·0	14·8	7.5
C	8·1	13·0	7·0	H	7·5	25·3	8·1
D	7·3	16·4	8·0	I	4·8	13·0	4·4
E	7·7	16·4	8·8				

The chief difficulties connected with the concentration arise from the intimate association of the constituent minerals with each other. This causes a low recovery of the galena, the concentrates produced containing no more than from 65 to 75% of the total lead contained in the ore: and it also prevents the production of high-grade zinc concentrates, those hitherto produced even with the help of magnetic separting operations, having contained no more than from 35 to 42% Zn. Various investigations made with the view of determining the extent to which fine crushing would improve the concentration have demonstrated that the best practical results would be obtained by first concentrating the ore after crushing it fine enough to permit of the whole passing through from 0·125 to 0·1 in. ($\frac{1}{8}$ to $\frac{1}{10}$ in.) screen meshes, and then reconcentrating the heavier of the residual products of this primary operation after crushing them fine enough to pass through from 0·04166 to 0·03125 in. ($\frac{1}{24}$ to $\frac{1}{32}$ in.) screen meshes; and it seems certain that appreciably finer crushing for either operation would cause an undue loss of both lead and zinc in fine slimes that cannot be effectively concentrated. This method of conducting the concentration is adopted at some of the mines and seems likely to become the universal practice.

Crushing the Crude Ore.—At some of the mines the ore is tipped direct from the mine trucks into large breakers of the Gates type which are fixed over storage bins. The roughly broken ore is then dealt with by a unit of the plant consisting of a breaker of the Blake type, a pair of Cornish rolls, trommels with circular screen holes about 0·1 in. diameter, and a raff wheel or some other form of elevator for returning the rough ore from the trommels to the rolls. At other mines the arrangements are similar except that the ore is not submitted to the preliminary crushing with the Gates breakers, but is fed direct from storage bins into large Blake breakers, fixed over the Cornish rolls. In details the crushing plants at the various mills differ very considerably, but the differences in no case seem to be attended with marked advantages, and all that can be said concerning them is that the heavy slow running crushing plants are more successful than the lighter and quicker running plants. The compact ore is very hard and tough and the crushing plants supplied by manufacturers of repute generally require altering and strengthening very considerably before they will deal with it effectively. A heavy, slow-running plant consisting of a Blake breaker with a 9×18-in. jaw aperture running at 200 revolutions per minute, and a single pair of Cornish rolls, 33 in. diameter and crushing face 20 in. wide, running at 15 revolutions per minute, will crush an average of 10 tons of the compact ore per hour, dealing with it as coming from the mine and reducing it fine enough to pass through 0·1-in. screen holes. The average crushed ore can be graded into four practically equal portions the particles of which have approximately the

following diameter measurements: (1) 0·125 to 0·0417 in. ($\frac{1}{8}$ to $\frac{1}{24}$ in.). (2) 0·0417 to 0·0208 in. ($\frac{1}{24}$ to $\frac{1}{48}$ in.). (3) 0·0208 to 0·0104 in. ($\frac{1}{48}$ to $\frac{1}{96}$ in.) and (4) Less than 0·0104 in. ($\frac{1}{96}$ in.).

Jigging the Crushed Ore.—At all of the mills the crushed ore is conveyed direct from the crusher trommels into the jigs without any attempt to classify it; at some of the mills, however, the fine slimes are roughly separated from the crushed ore by hydraulic separators of various forms. The jigs used are either large double acting piston jigs or jigs of the Hancock type.

The former do not call for any special comment; the chief feature of the latter is the swinging sieve bed to which a vanning movement is given by suitable mechanism placed under the hutch. These jigs treat from 5 to 10 tons of ore per hour each, the quantity varying with the character of the ore and the manner in which the jigs are controlled. The concentration products are wholly worked through the sieve beds, iron punchings or some suitable substitute being used for the "ragging" or sieve bedding. The products of the jigging operation are: (1) argentiferous galena concentrates, the bulk of which contains from 60 to 65% Pb and from 16 to 35 oz. silver per ton; (2) zinc middlings consisting chiefly of blende, rhodonite and garnet and containing from 7 to 10% Pb, 15 to 25% Zn and from 5 to 10 oz. silver per ton; (3) tailings consisting chiefly of quartz, rhodonite and blende and containing from 4 to 7% Pb, 10 to 20% Zn, and 4 to 8 oz. silver per ton; and (4) slimes which are either separated from the crushed ore before it enters the jigs, or from the jig middlings or jig tailings after they leave the jigs; these slimes contain from 10 to 25% Pb, 15 to 25% Zn and 8 to 20 oz. silver per ton. At some of the mills the zinc middlings are recrushed (chiefly by Heberli mills) fine enough to pass through 0·0417-in. ($\frac{1}{24}$ in.) mesh screens and then rejigged, producing a further small quantity of galena concentrates, together with products similar to those produced in the first jigging operations. Investigations have been repeatedly made with the view of determining the extent to which the jigging operations would be improved by a preliminary classification of the ore, and the information gained has been such as to discourage any changes in this direction. Very conclusive evidence bearing upon this question is afforded by systematically grading representative samples of the various jig products and examining the resulting sized portions of the samples with the view of ascertaining the character and composition of the various particles. The following tables show a summary of the results obtained by thus dealing with average samples of the jig products, taken daily for a period of one month at the mill of the Broken Hill Proprietary Block 16 mines. The ore was treated with Hancock jigs without any preliminary classification or slime separation, but the slimes were separated from the middlings and tailings after they left the jigs by a combination of hydraulic separators and fixed inclined sieves. In these tables the mesh figures mean the number of holes per linear inch.

(1) The first grade concentrates consist almost wholly of particles of galena and garnet, the latter being present in very small quantities. The zinc contents chiefly occur as blende attached to the galena particles, little or no free blende being present.

CONCENTRATION TESTS SHOWING PROPORTIONATE AMOUNT AND COMPOSITION OF JIG PRODUCTS. (DAILY AVERAGES FOR ONE MONTH.)

Size of Material.	(1) First Grade Concentrates.				(2) Second Grade Concentrates.			
	Proportion of whole.	Lead.	Zinc.	Silver.	Proportion of whole.	Lead.	Zinc.	Silver.
	%	%	%	Oz. per ton.	%	%	%	Oz. per ton.
Average sample	100·0	70·1	4·2	28·5	100·0	50·3	7·9	23·5
Retained on 24-mesh sieve	15·1	65·7	6·7	28·0	13·7	43·2	14·0	27·4
Passed 24, retained on 40-mesh sieve	29·1	69·8	5·2	31·0	22·8	45·4	11·7	24·3
Passed 40, retained on 60-mesh sieve	19·5	70·2	4·2	28·5	17·8	50·0	8·4	22·7
Passed 60, retained on 80-mesh sieve	13·3	69·1	3·4	27·0	13·9	49·5	6·8	23·3
Passed 80, retained on 100-mesh sieve	13·0	67·6	3·1	25·3	17·6	53·2	5·1	21·8
Through 100-mesh sieve	10·0	75·4	2·9	26·6	14·0	62·3	4·2	24·5

Size of Material.	(3) Zinc Middlings.				(4) Tailings.			
	Proportion of whole.	Lead.	Zinc.	Silver.	Proportion of whole.	Lead.	Zinc.	Silver.
	%	%	%	Oz. per ton.	%	%	%	Oz. per ton.
Average sample	100·0	8·3	14·0	8·0	100·0	4·6	10·5	4·9
Retained on 24-mesh sieve	38·1	9·8	13·6	9·0	51·3	5·0	8·6	4·4
Passed 24, retained on 40-mesh sieve	33·8	6·3	14·2	7·1	26·6	3·8	11·2	4·2
Passed 40, retained on 60-mesh sieve	15·1	5·2	14·7	6·9	11·2	3·3	13·2	4·4
Passed 60, retained on 80-mesh sieve	5·5	4·4	14·2	6·2	3·8	3·4	12·4	4·5
Passed 80, retained on 100-mesh sieve	3·6	5·3	13·7	6·2	2·8	3·2	13·4	4·9
Through 100-mesh sieve	4·0	14·8	14·7	11·7	4·0	12·8	14·2	10·6

(2) The second grade concentrates consist almost wholly of particles of galena and garnet together with a few particles of blende and rhodonite: the greater part of the zinc occurs as blende attached to the galena particles.

(3) The zinc middlings consist of particles of blende, rhodonite and garnet together with a little quartz.

(4) The tailings consist of particles of blende, rhodonite, feldspar and quartz, the last named being present in considerable proportions.

Only such portions of the middlings and tailings as will pass through a 60-mesh sieve contain free galena, and such of this as is retained on a 100-mesh sieve contains only from 1 to 2%, while that which will pass through the 100-mesh sieve contains about 10% of free galena. The fact that the jigs ordinarily produce, on the one hand, a quantity of high-grade concentrates that will pass through an 80-mesh sieve: and on the other hand, zinc middlings and tailings, none of which contain free galena except such as will pass through an 80-mesh sieve, clearly demonstrates that absolutely nothing would be gained by classifying the crushed ore before jigging it. The rhodonite particles contained in those portions of the middlings and tailings that are retained on a 24-mesh sieve contain from 3 to 5% Pb, from 5 to 6% Zn and from 3 to 5 oz. silver per ton, while the rhodonite particles contained in such portions as will pass through a 24-mesh sieve contain from 1 to 2% Pb, from 2 to 3% Zn and from 2 to 3 oz. silver per ton. Galena is set free on grinding both of these products finer, but only the coarser product would produce enough galena to pay for cost of recrushing

and reconcentrating. The blende particles contained in such of the middlings and tailings as are retained on a 24-mesh sieve contain from 10 to 15% Pb, from 25 to 35% Zn and from 8 to 15 oz. silver per ton: and those contained in such as will pass through a 24-mesh sieve contain from 7 to 10% Pb, from 30 to 35% Zn and from 7 to 10 oz. silver per ton. A small quantity of galena concentrates could be obtained by regrinding and reconcentrating both of these products, but only the coarser product would produce enough concentrates to pay for the cost of treatment. The coarser quartz particles contain from 1 to 2% of lead, and the finer particles are almost free from lead.

Treatment of Slimes.—The slimes separated from the crushed ore and jig products are settled and classified, and the graded pulp is treated on various forms of shaking tables and vanners, the shaking tables being mostly used for dealing with the coarser material, and the vanners for treating the finer material. The Wilfley and Phœnix are the most generally used shaking tables and the Luhrig the most generally used vanner. The Phœnix table is a local invention and its general construction is shown in Figs. 1 and 2.

The products of the slime concentrating operations are: (1) Galena concentrates containing from 45 to 75% Pb and from 16 to 32 oz. silver per ton. (2) Slime tailings containing from 3 to 8% Pb, from 15 to 25% Zn and from 4 to 10 oz. silver per ton.

At some of the mills the slime tailings and the floating slimes are settled together in large dams and the whole is regarded as a product stocked for future treatment by some process which has yet to be applied. At other mills the slime tailings are separated from the floating slimes by hydraulic separators and other appliances and accumulated as dump products, while the floating slimes are collected in dams and sent to the smelters, who treat them for their lead and silver contents. The following table shows the character of the slimes tailings and floating slimes which are being produced at the mill of the Broken Hill Proprietary Block 14 mines at the present time.

Size of Material.	(1) Slime Tailings.				(2) Floating Slimes.			
	Proportion of whole.	Lead.	Zinc.	Silver.	Proportion of whole.	Lead.	Zinc.	Silver.
	%	%	%	Oz. per ton.	%	%	%	Oz. per ton.
Average sample.	100·0	5·6	15·0	7·0	100·0	20·8	15·2	14·9
Retained on 60-mesh sieve.	25·2	7·5	14·4	7·5				
Passed 60, retained on 80-mesh sieve	22·1	4·5	14·4	6·7				
Passed 80, retained on 100-mesh sieve	30·1	3·7	15·8	5·8				
Passed 100-mesh sieve.	22·3	6·9	17·2	8·1				
Retained on 120-mesh sieve.					14·5	19·0	14·8	13·8
Passed 120-mesh sieve.					85·5	21·3	15·6	15·3

The slime tailings and also the floating slimes consist chiefly of particles of quartz, rhodonite, garnet, blende and galena; the slime tailings containing very little and the floating slimes considerable proportions of free galena, the whole of which is in a much more finely divided state than the greater portion of the other constituents. The rhodonite particles in the slime tailings contain from 1 to 2% Pb, 2 to 3% Zn and 3 to 4 oz. silver per ton: and the blende particles contain from 7 to 10% Pb, 30 to 35% Zn and 7 to 10 oz. silver per ton.

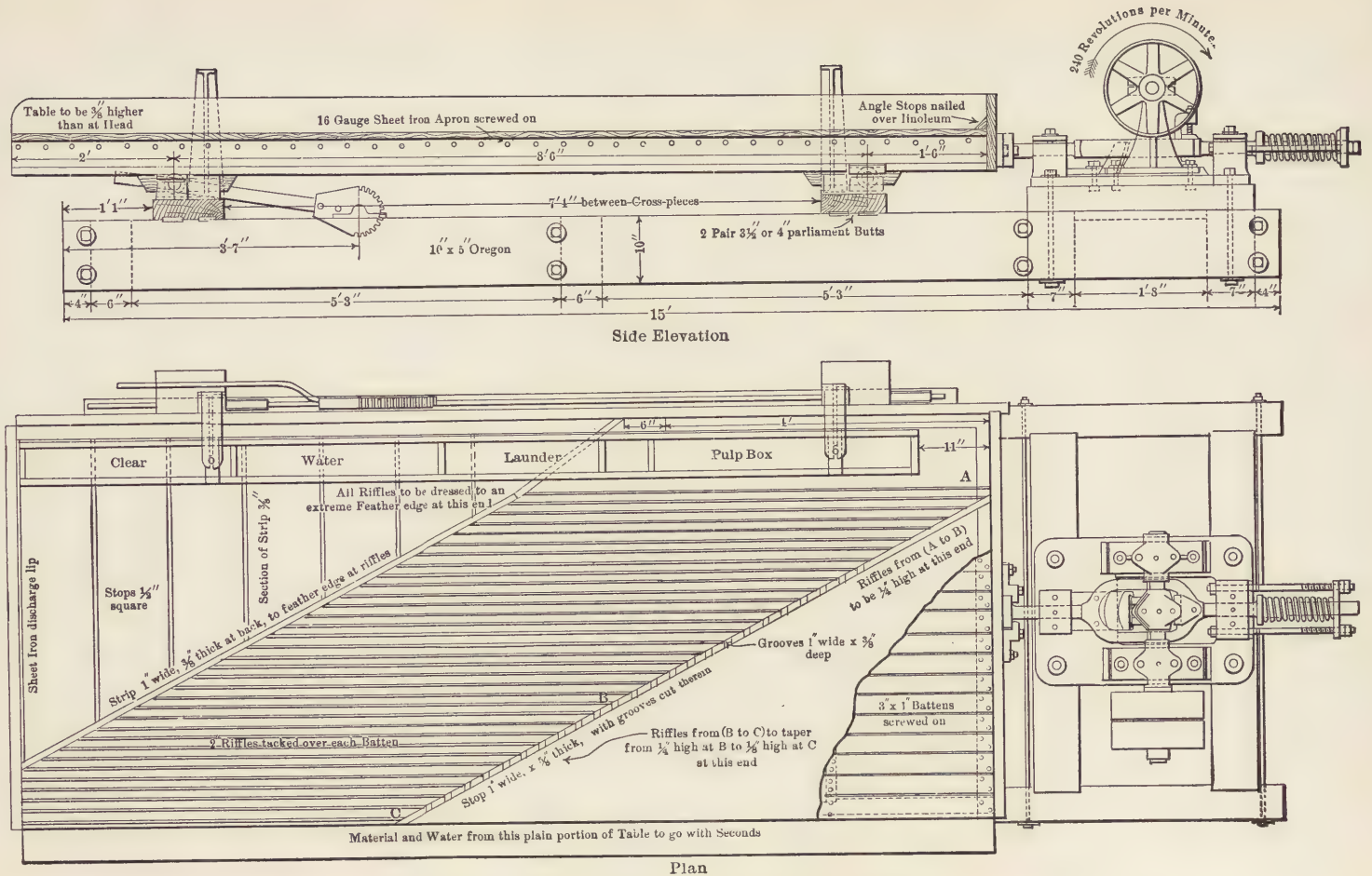


FIG. 1.—THE PHŒNIX ORE DRESSING TABLE.

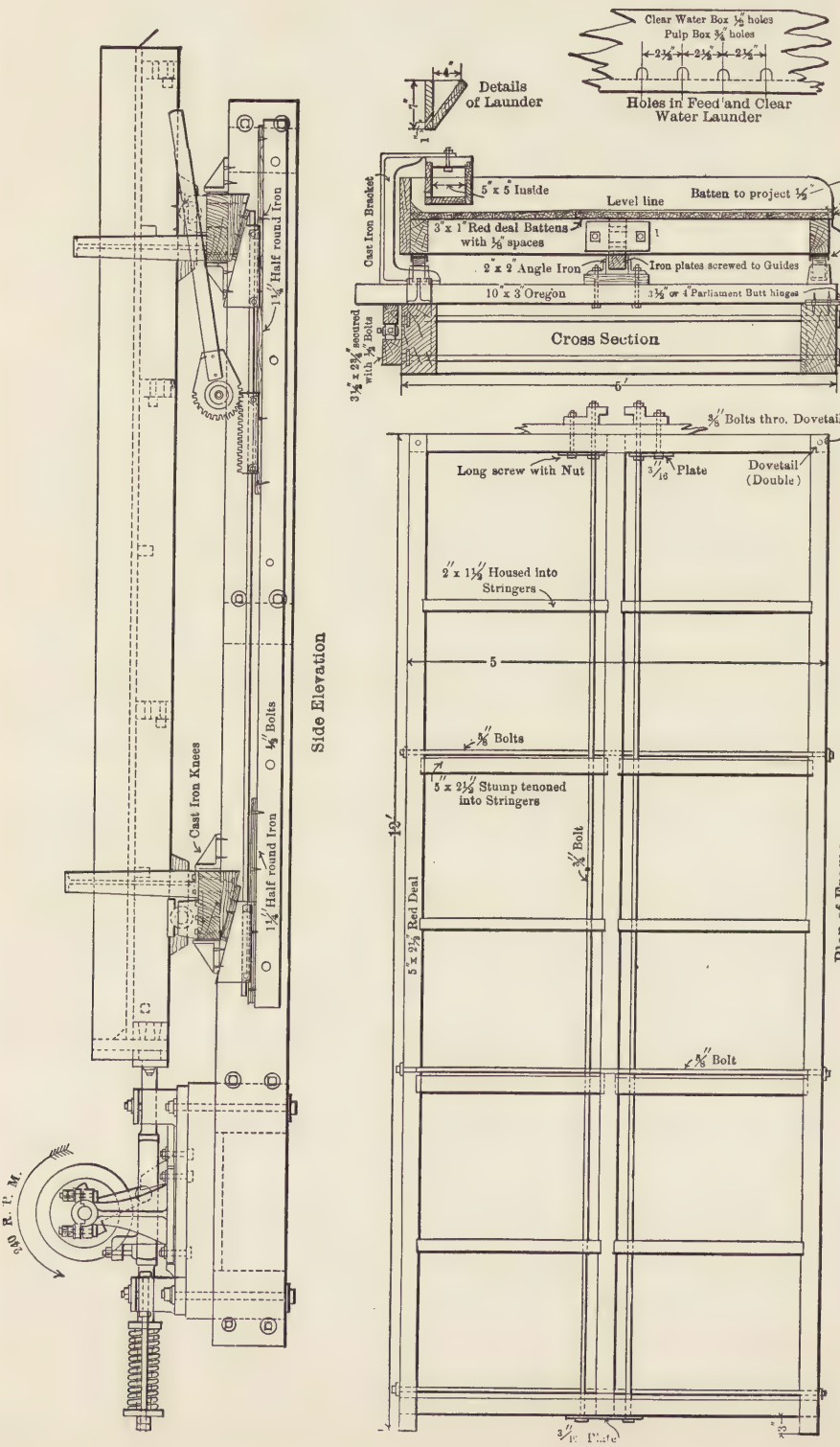


FIG. 2.—THE PHŒNIX ORE DRESSING TABLE.

Scope of Concentrating Operations.—The results of several years' practice indicate that future improvements in concentrating the Broken Hill sulphide ore will find their limits in the recovery of from 75 to 80% of the lead content and from 50 to 60% of the silver content in the form of silver-lead concentrates and other smelting products, and in the production of a small proportion of worthless siliceous tailings and a large proportion of "zinc middlings" containing from 5 to 8% Pb, from 15 to 25% Zn and from 5 to 10 oz. silver per ton. The presence of a large proportion of garnet and rhodonite having practically the same specific gravity as blende, and the fact that even very small particles of separated blende contain from 6 to 10% of lead in the form of attached galena, indicate that it is useless to look to concentration either for the recovery of appreciably larger proportions of galena concentrates or for the production of marketable blende concentrates. These considerations have brought about attempts to treat the zinc middlings by chemical and electrolytic processes and magnetic separating operations. So far no chemical or electrolytic process has yet been successfully applied, but some measure of success has attended magnetic separating operations, and it now seems certain that magnetic refraction will in the near future play an important part in the treatment of the accumulating dump products.

Production of Blende Concentrates by Magnetic Separation.—Two magnetic separating works were erected at Broken Hill by a German syndicate and successfully operated for a time, while the price of zinc was high and exporting conditions were favorable. The method of producing zinc concentrates adopted at these works was that of magnetically separating the most suitable concentration products obtainable into three portions, *viz.:* (1) Non-magnetic material consisting chiefly of quartz, blende containing large portion of lead, and free galena, the whole containing from 18 to 20% Pb, from 18 to 22% Zn and from 8 to 12 oz. silver per ton. (2) Weakly magnetic blende concentrates containing from 8 to 10% Pb, from 35 to 42% Zn, and from 8 to 12 oz. silver per ton; and (3) Strongly magnetic material consisting chiefly of rhodonite and garnet and containing from 4 to 6% Pb, from 6 to 8% Zn, and from 4 to 6 oz. silver per ton. The material operated upon was zinc middlings containing considerably more zinc (over 27%) than the average middlings obtainable. The zinc product was shipped to European zinc smelters, and the other products were dumped for future treatment. The works are now shut down, as blende concentrates such as those obtained cannot at the present time be profitably produced and exported.

The above-mentioned operations as well as exhaustive experimental operations carried on by some of the mining companies have rendered it evident that the average blende concentrates obtainable from the Broken Hill sulphide ore are unavoidably a complex product containing from 30 to 40% Zn, from 6 to 12% Pb, and from 6 to 12 oz. silver per ton. As the treatment of a product of this description calls for operations of a more complicated character than those ordinarily carried on at zinc smelting works, this product cannot be readily sold at a price representing its real commercial value, and the absence of a proper market for it is the chief obstacle the Broken Hill mining companies have to encounter in carrying the treatment of the sulphide ore to its full issue.

RECENT CONTRIBUTIONS TO THE SCIENCE OF ORE-DEPOSITS.

By R. W. Raymond.

After the classic work of Daubrée, and the famous controversy initiated by Prof. Sandberger's revival of the "lateral-secretion" theory, the next important event in the history of the science of ore-deposits (*Erzlagerstättenlehre*) was the appearance, in 1893, as a contribution to the *Transactions of the American Institute of Mining Engineers,* of the treatise on the Genesis of Ore-Deposits, by Franz Posepny, the distinguished Austrian mining-geologist, and for years the representative of this science as a professor in the ancient mining school at Przibram, Bohemia. In recognition of his thorough and suggestive work in this department, Prof. Posepny had been already elected an honorary member of the Institute; and this remarkable paper, embodying the results of his long and active studies, was his acknowledgment of that recognition. As thus issued, in an English translation, before it appeared in Europe, it became the starting-point of a fruitful discussion, in which foreign as well as American authorities took part. Besides sending more than 3,000 copies of the pamphlet-edition of the paper and its discussion to individual members and technical journals and societies throughout the world, and including the same material in its annual volumes of *Transactions,* of which an equal number were printed, the Institute published a special volume, containing only this material, and known as "the Posepny Volume." The edition of this book was rapidly exhausted, notwithstanding the large previous editions above mentioned. It is to be reprinted with additional material from the *Transactions* of the Institute; and I mention here the exhaustion of the first edition as a striking proof of the interest in this subject aroused by the contribution of the distinguished author, who died before the volume which crowned his fame had left the press, and whom we do not cease to mourn and to miss.

It is not the purpose of this article to rehearse, either in detail or in abstract, the theories and arguments of different contributors to the literature of the science of ore-deposits, but rather to indicate the nature and weight of each important contribution, leaving the student of this science to that consultation of the authorities in which, I trust, my remarks may be helpful as a guide.

Without underrating the many merits of Prof. Posepny's treatise, such as the clearness of its argument, the abundance, felicity, and accuracy of its illustrations, and the candor and modesty, combined with earnest conviction, which made it a model for imitation, I may say, that, in my judgment, its most effective and timely features were the following:

1. The clear distinction which it drew between the "vadose" and the "deep" circulation of water underground, and which superseded the use of such vague terms as "ascending" and "descending," by definitions independent of mere local direction.

2. Its vigorous opposition to a certain form of the "lateral-secretion" theory, which, I think, was fairly identified with the form in which that theory was revived by Prof. Sandberger, though less extreme "lateral-secretionists" did not accept that statement, or admit that Posepny's arguments conclusively overthrew the theory, as they held it.

3. In connection with this particular controversy, the proposition that such theories tended to transfer the study of ore-deposits from the primary study of the facts observed underground to the evolution of chemical theories, and the earnest plea for careful "objective" reports of what might be called "the facts in place."

This last particular was perhaps the most profoundly important of all—not by reason of any implied disparagement of chemical research, but as emphasizing the great need of close, accurate and unbiased descriptions of actual phenomena, preceding the formation of general theories.

When the United States Signal Service established its "weather-bureau," for the study of meteorological conditions, the Smithsonian Institution already contained stacks of "weather observations," accumulated through many years and contributed by well-meaning persons who had laboriously recorded and reported the readings of thermometers, barometers, anemometers and rain-gauges, without ever adjusting the instruments themselves to any common standard, or observing any definite precautions to secure accuracy and uniformity. This vast aggregate of misdirected industry was entirely worthless to science; and similar instances could be adduced from every department of physical inquiry. The study of ore-deposits also has suffered in this respect. Innumerable hasty, superficial, prejudiced, or otherwise erroneous descriptions of phenomena have burdened its literature. The text-books have handed down from one generation to the next the crude opinions and incomplete illustrations furnished by pioneers; and the framers of theories have practiced the methods of induction upon these inadequate and unreliable data. Posepny's call for new and more trustworthy primary material was timely and fruitful. His own monographs had set a good example; and, while he was not alone in this respect, I think we may fairly give him the credit for stimulating, in the most important of all fields for this study—namely, the virgin field of the United States—a great activity in "objective" work. I shall do justice to the work of this kind already in progress, in the skillful hands of American field-geologists, when I recur, at a later point in this sketch, to this branch of the subject.

4. As the final important service rendered by Prof. Posepny's treatise, I may mention its proposition of a genetic classification of ore-deposits. This attempt was not unprecedented; but it fell upon a prepared soil, and did much, I think, to promote the true view of such classifications. I might even go further, and say that its main value lay in its implied discouragement of the premature attempts at a final classification, and especially of the mongrel classifications,

professing to satisfy at once the miner and the geologist. Such arrangements of the observed facts may do well enough as tables of contents, or schedules for lectures in mining schools; but they are likely to be hindrances, rather than helps, in the scientific study of ore-deposits. I may speak freely on this point, since I published, some 31 years ago, a classification of this kind,* which has recently been recalled by others, and pronounced to be as good as any of the later ones. I accept the compliment with due pleasure, modified somewhat by my present conviction that none of them are good for much, beyond temporary convenience. We might almost say of such classifications, as Thackeray's "Jeames Plush" said of spelling—"Hevery gen'leman 'as 'is hown!"

Posepny's classification was avowedly genetic, and not at all designed to assist exploitation. He did not offer it as final; but I think it sounded the knell of the endeavor to frame, for scientific purposes, a classification adapted to guide mining operations. Such a proposed classification, it is true, is contained in a recent paper, from a source entitled to respect, namely, Mr. C. R. Keyes,† a practical geologist and geological author of repute.

Mr. Keyes starts with the proposition: "The great thing sought for in the classification of ore-bodies is a system that is genetic as far as possible, that is practical in application, and that will aid in their discovery and development. Such a scheme should be made so that the most ordinary miner may use it."

This proposition, in my judgment, states an aim as impossible as it is undesirable. The most ordinary miner must learn a great deal, before he can use a scientific classification; and truly scientific classifications ought not to be lowered to his comprehension or use. On the other hand, a really useful miner's classification will not be genetic at all; but will group ore-deposits according to those features which are involved in prospecting and in mining. The attempt to combine the two purposes is injurious to each. Mr. Keyes' own classification might be cited as an example, but for the fact that it does not fairly carry out even his own ideal. Moreover, it violates at the outset the fundamental requirements of a classification: namely, that the groups of each rank shall be of equivalent value, and that the primary groups shall be sharply distinguished. His three vague primary groups are based upon features of form and position, which offer no profound distinctions whatever; and they are not even of equal value. Thus he divides ore-deposits into "Hypotaxic" (meaning imperfectly arranged, and described as "mainly surface-deposits"); "Eutaxic" (well arranged, "chiefly stratified formations"); and "Ataxic" (not arranged, "predominantly unstratified and irregular bodies"). And the first of these classes he creates, not because any genetic consideration calls for it, but because it is "best considered independently of the other two"! Thus he starts with three primary groups, two of which are professedly natural, and the third is convenient, while not one of the three is sharply defined. Much good sense and good description contained in other parts of this paper is impaired by the hopeless confusion of its "classification," ag-

* *Statistics of Mines and Mining*, etc., by Rossiter W. Raymond, U. S. Commissioner of Mining Statistics, Washington, 1870. Part III., "Mineral Deposits," p. 448. Quoted (1894) by Mr. Rickard, *Transactions of the American Institute of Mining Engineers*, Vol. XXIV., p. 943.

† "Origin and Classification of Ore Deposits," *Transactions of the American Institute of Mining Engineers*, February, 1900.

gravated by an unnecessarily novel nomenclature, the guiding principle of which seems to have been a fear of tautology. "Crevice-accretion" and "fold-filling" are categories under one group; "fissure-occupation" comes under another; and "selective dissemination" is distinguished from "preferential collection," "cumulation" from "accumulation," and so on, through an ingeniously chosen variety of terms which convey no essential differences of meaning. And if the miner desires to know just where lenses, pockets, masses and veins come in, he will find in the column added for his use, that they belong "in part" here, and "in part" there.

But I do not wish to criticise harshly the imperfections of this latest attempt to produce a classification of this sort. There are plenty of them on hand; and this may go with the rest, for use whenever and wherever it may prove useful. My main point is, that we do not need in science anything of that kind, any more than we need that a scientific zoölogy shall be such as any ordinary hunter can use in hunting, or that scientific botany shall be based upon horticulture.

Meanwhile, as to genetic classifications, the more we have of them the better, provided we remember that the final classification is not yet. What we still need is the accumulation of accurate data, and their reduction to order; the study of actual processes and occurrences, and the quantitative determination of their rôles and relations. We still need, perhaps, to agree upon the bottom distinction, upon which to base the primary division of ore-deposits. So far, I think, Posepny's distinction between the "Idiogenites" and the "Xenogenites" is the clearest and most profound which has been suggested. It was not original with him; but I think the use he made of it was, on the whole, new. Yet he would have been the first to welcome a better primary distinction. As to the secondary and ternary divisions, we are all at sea. But we are beginning to see whither we are sailing; and the last 10 years have brought us increasing light.

This light has come principally from three quarters: (1) the increased abundance and accuracy of field-observations in geology and in mining; (2) the advance in extent and quantitative precision of geological theory; and (3) the similar advance in inorganic chemistry, especially as concerns the reactions occurring in nature among rocks, liquids and vapors, and the synthetic reproduction of them in the laboratory.

We can all remember how lately we talked off-hand of "upheavals," "convulsions," "dynamic forces," and the like, stopping short at such phrases as if we had reached the *Ultima Thule* of inquiry; and we have not yet ceased to speak of "the ore-bearing solutions" as going up or down or sidewise and "depositing" things. These glittering generalities will soon be relegated to mining prospectuses. The progress achieved in petrography with the aid of the microscope; the thorough study of the igneous rocks and their derivations; and the revelations of thermo-chemistry, as well as of chemical analysis and synthesis, now demand, in our explanations of ore-deposition, more definite and detailed particulars. What was the "dynamic force"? When was it operative? What did it effect? What was the circulating solution? By what reaction did it "deposit" ores? How was it propelled? These and many other similar questions must be an-

swered; and the answers to many of them are coming into view on the horizon, if we have not certainly reached them.

Without ignoring the great services of such foreign investigators as Daubrée, De Launay, Vogt, Stelzner, etc., we may fairly claim that much has been contributed to this progress by Americans, and especially by the members of the United States Geological Survey, and of the Institute of Mining Engineers. This was to be expected, as the result of the unparalleled liberality with which the Survey has been supported by Congress; the excellent preparatory training of field-observers in our scientific schools; their ample practice in the field; the vast and varied new territory open to their study; and the great vigor and rapid growth of the American mining industry, which has furnished abundant underground data for comparison. For some years, the results of these conditions were not fully apparent. The ultimate bearing of new geologic, petrographic and microscopic investigations was not at once generally perceived. Monographs upon mining districts like the Comstock, Eureka, Leadville, etc., came almost or quite too late to guide the miner in his work; and their value as stones for the future edifice of a comprehensive generalization was but partially recognized. A few leading authors (among the foremost of whom I think Mr. Emmons should be specially named) had already published fragments of the great new summary which no one man could make. But Posepny's paper of 1893 set the pace; and the Washington meeting of the Institute, in February, 1900, with the Richmond meeting of a year later, suddenly disclosed the accumulated result of much patient and thorough work. It was like the rise of the Nile in Abyssinia, where, as described by Sir Samuel Baker, innumerable streams in the mountains unite their tributary freshets to make a mighty flood.

The paper of Prof. Van Hise* was a surprise, even to his colleagues in the United States Geological Survey. His work in the iron-ore regions of Lake Superior, though concerned with many problems of metamorphism, etc., involved also in the general science of ore-deposits, was not known to have led him into such special researches in other than iron-ore deposits as would result in a general treatise on the subject. Others who had long been gathering materials for such a treatise found their work largely done for them by this laborer in a single corner of the great field. Indeed, both the strength and the weakness of Prof. Van Hise's paper were due to its peculiar origin. Its strength lay in its clear statement and combination of certain fundamental facts in dynamic geology —such as the folding, fracture, flexure and flow of rocks; the different zones of the earth's crust, etc.,—and its suggestive use of the phenomena of underground water-circulation, as chief factors in the formation of ore-deposits. The treatise is in fact a masterly condensation and application of the previous essays of the author† and the investigation of Slichter into the movements of groundwater.‡ Beyond question, the result has proved in the highest degree suggestive

* "Some Principles Concerning the Deposition of Ores," by C. R. Van Hise, *Transactions of the American Institute of Mining Engineers*, February, 1900.

† Such as his "Principles of North American Pre-Cambrian Geology," *XVIth Annual Report of the United States Geological Survey* (for 1894-5; and published in 1896), Part I., p. 589; "Metamorphism of Rocks and Rock Flowage," *Bulletin of the Geological Society of America*, Vol. 9, (1898) pp. 295, 318.

‡ Theoretical Investigation of the Motion of Ground-Water," by C. S. Slichter *XIXth Annual Report of the United States Geological Survey* (for 1897-8), Part II., p. 305.

and illuminating. On the other hand, the weakness of this paper, directly traceable to its too narrow basis as a generalization, is that it not only explicitly omits from consideration, besides sedimentary deposits, those of igneous origin, but excludes the collateral agency of igneous magmas, gases, etc., as a factor in the formation of ore-deposits not directly igneous, or in the movement of solutions active in such formation. The first omission is not open to criticism. An author has the right to limit his subject as he chooses, and may not be complained of, because he did not choose otherwise. But the second omission may fairly be questioned—especially when it leads Prof. Van Hise to claim that the flowage of underground water is caused chiefly by gravitative stress.

Before considering this proposition, I will cite briefly the "premises" of Prof. Van Hise, as he calls them; though I think many of them might as well be termed conclusions or propositions. Indeed they seem to be the "principles" stated in the first part of his paper and applied in the second. At all events, they are as follows:

1. The greater number of ore-deposits [are neither directly igneous nor sedimentary, but] are the work of underground water.

2. The material for ore-deposits is derived from rocks within the zone of fracture [*i.e.*, the zone, nearer the surface than that of "flowage," in which rocks are deformed by rupture and movement of the separated parts].

3. By far the major part of the water depositing ores is meteoric.

4. The flowage of underground water is caused chiefly by gravitative stress.

Of these four propositions, the first is likely to find general acceptance, especially as applied to ore-deposits as they now exist, apart from their original sources or forms. But the origin of the metallic ores, at least, may still be referred with strong probability to the igneous rocks, even of Posepny's barysphere; for the second proposition seems to ignore the facts of magmatic extrusion and expulsion, which play so great a part in furnishing the material of ore-deposits.

The third proposition also is probable enough, since the amount of water in the earth's crust not meteoric is not only indeterminate, but doubtless relatively small. Yet this amount may have been, and may still continue to be, the most important initial agency in the series which ends with the concentrated deposits of ores. This has been shown by Profs. Vogt and Kemp, in their comments upon Prof. Van Hise's paper.

Finally, the fourth of the above propositions does not meet with acceptance. It seems, indeed, to be theoretically unsound, as well as discordant with many observed facts. But the disproof and rejection of it would not seriously impair the beauty and value of Prof. Van Hise's remaining argument. He seems himself to feel this; for, after conceding that other causes, such as earth-movements, deforming the rocks, may squeeze the water, he continues (p. 24): "But whatever the cause of the flow of underground water," etc.—after which he proceeds with the reasoning which did not really depend upon his eccentric gravity-theory. This theory, by the way, has been successfully combatted by Prof. Kemp, who has showed that the effect of gravity, reinforced by the difference of temperature

between the two columns of an underground circulation, would not be adequate to explain the observed phenomena.

Concerning the "classification" of ore-deposits with which the paper ends, little need be said. Three primary groups are made: (A) ores of igneous origin; (B) ores which are the direct result of the processes of sedimentation; and (C) ores which have been deposited by underground water. These are fairly genetic and natural distinctions, though I am not sure that they are as fundamental as the one which, in Posepny's scheme, sharply divides all ore-deposits into two classes. But Prof. Van Hise offers no subdivisions of (A) and (B); while he subdivides (C) into : (a) ores which are deposited by ascending waters alone; (b) ores which are deposited by descending waters alone; and (c) ores which receive a first concentration by ascending, and a second by descending waters. This classification is admirable for the purpose of his discussion. Aside from that use, it suffers under several disadvantages, among which one of the greatest is, that it is indefinite in the worst way, because a single ore-deposit (in the practical sense of miners and economic geologists) may belong to all these classes at once, showing at one point the characteristics of (a), elsewhere, those of (b), or (c). In fact, class (c), as will be presently shown, fairly covers an interior feature in many ore-deposits, but not the deposits themselves, considered as larger wholes.

But this same class (c) has a highly important bearing upon the old-time theories of "ascension" and "descension," as well as "lateral secretion," which, so far as it really occurs, must occur as part either of the ascending or of the descending limb of circulation. Prof. Van Hise's acute analysis leaves truth in all these theories and concedes the whole field to none of them—just as his fellow-laborers will doubtless recognize the value, and seek, at the same time, to trace the limitations, of his views.

His admirable general discussion of the chemical and physical work of underground waters, systematizing much that was known already, and adding much in the way of suggestion, was effectively reinforced by the papers of Messrs. Emmons* and Weed.† These essays supported and extended the view of Prof. De Launay as to the secondary redistribution and re-formation of ores. It seems to me that they add an important and original feature to his previously published views,§ and to those of Penrose,‡ by clearly stating a process not limited in

* "The Enrichment of Gold and Silver Veins," *Transactions of the American Institute of Mining Engineers*, Vol. XXX., p. 177. ‡ *Journal of Geology*, 1894, II., p. 39.

† The Secondary Enrichment of Ore Deposits," *Idem.*, Vol. XXX., p. 424.

§ *Annales des Mines*, Vol. XII., (1897), p. 119. This article is summarized by Prof. Kemp (*Mining and Metallurgy*, Jan. 1, 1901) as follows:

"Previous to this time it was thought that the rearrangements of the ores in a vein were limited to the portion above the permanent water-level—that is, to the gossan. The resulting products were chiefly oxidized ores, native metals or greatly enriched sulphides, such as copper glance. In the case of copper it was especially well known that the metal from the upper parts of veins became concentrated at the water-level. These changes had been discussed at length by Penrose (*Journal of Geology*, 1894, II., p. 288) and under the old conception the only way in which enrichments could reach a point below the permanent water line was, as suggested by Kemp (*Ore Deposits*, 1893, p. 39), by a subsidence of the country, by the consequent readjustment of the drainage and the rise of the level of the ground water.

"De Launay first develops the conception of the globe as having been in its early history a metallic core surrounded by a corroding bath of molten, siliceous rocks, like a button in a scorifier. Certain parts of the slaggy exterior received especial richness of metals and in time supplied them to circulating waters, which thus developed deposits of comparatively lean ones. Later on the metals of all sorts, alkalies, alkaline earths

depth by the ground water-level. But the question of priority has little importance in this case. The pack was not merely on the scent; it had caught up with the fox, and all the keen pursuers were gathering to one point. It matters little who reached it first.

The paper of Mr. Emmons states in a temperate, conservative, philosophical tone the present state of the evidence and the theory of secondary enrichment. Its weak point (frankly avowed by him) is the absence of detailed discussion of the chemical reactions involved. This has been the chief hindrance to the solution of the problems of ore-deposition heretofore. The geologists did not presume to explain the chemistry of those problems; and the chemists were, until recently, confined by laboratory traditions and experience, which did not fully represent natural conditions. Following Daubrée's great initiative, however, they have speedily closed the gap between the laboratory and the field; and the new chemical laws (concisely stated by Mr. H. N. Stokes on page 39 of Mr. Emmons' paper) have wonderfully illuminated their experimental results.

Mr. Weed's paper,* though very similar in title to that of Mr. Emmons, is not a mere reiteration of its statements. It is characteristically a reinforcement, giving not only field-illustrations, but also suggesting formulas of the chemical reactions involved.

Not less brilliant, and perhaps even more novel and thorough in its way, is the paper of Mr. Lindgren,† also presented at the Washington meeting of the American Institute of Mining Engineers, February, 1900, in which the study of pseudomorphs, aided by the resources of both microscopy and chemistry, was made the basis of a generalization richer in detail as well as broader in scope than had been made hitherto. Not having the space in this article for an analysis of its contents, I cannot do better than quote the remarks of Prof. R. Beck of Freiberg, contributed to the late Richmond discussion:

and heavy metals alike renewed their migrations, largely through oxidation, and formed enriched ore bodies They were not all oxidized, because such minerals as gray copper, ruby silver, copper glance, silver glance and others are often cited as results of the process, and although it is stated that, strictly speaking, the level of the ground water marks the limit of the principal chemical changes, yet in the detailed discussion it is not made a line of sharp demarkation."

On the other hand, in his last article on "The Variations of Metalliferous Veins in Depth," published in the *Revue Générale des Sciences*, after describing the two zones, respectively *above* and *below* the ground water-level, he uses the following language (as translated by Mr. Emmons, in his contribution to the late discussion before the American Institute of Mining Engineers at the Richmond meeting):

"A body situated in this zone of permanent waters below this hydrostatic surface (which may have a very complicated form) finds itself in the condition of a wooden pile, which, remaining always immersed in water, suffers no change. On the other hand, above the hydrostatic surface (the ground water-level) there is a perpetual movement of the waters, a bringing in of oxygen and carbonic acid, alterations of humidity and dryness, etc.; it is there only that are produced the secondary reactions of which there is question here, and by which all the upper parts of metalliferous deposits are thoroughly modified."

It seems clear that Prof. De Launay (the originality and value of whose contributions to the literature of this subject are beyond question) did not positively and definitely declare as a fact of importance, the occurrence, below the ground water-level, of the secondary processes here under consideration. But the question of priority in such a matter is of small importance.

* In addition to the paper already cited, Mr. Weed has treated the subject more or less directly in "Enrichment of Mineral Veins by later Sulphides," *Bulletin of the Geological Society of America*, (April, 1900), XII., 179; "Types of Copper Deposits in the Southern United States," *Transactions of the American Institute of Mining Engineers*, February, 1900. "Geology of the Little Belt Mountains," *XXIst Annual Report of the United States Geological Survey*, Part III, p. 421., etc.

† "Metasomatic Processes in Fissure-Veins," *Transactions of the American Institute of Mining Engineers*, Vol. XXX., p. 578. Mr. Lindgren read at the Richmond meeting of the American Institute of Mining Engineers, February, 1901, a paper on certain contact-deposits, throwing further light on the general subject, which has not yet been published.

"With regard to Mr. Lindgren's paper, I will frankly say that since the death of Stelzner nothing has appeared in which the methods of microscopic-chemical research have been applied with such splendid success to the subject of ore-deposits. I agree (with insignificant exceptions) so thoroughly with the conclusions which the author has drawn from his brilliant investigations, that it would be useless for me to offer at this time any detailed criticisms. I can only express my delight that Stelzner's method has found in Mr. Lindgren an adequate American representative, master at the same time of the European literature of the subject."

At the Richmond discussion, already repeatedly mentioned, important new additions were made to the literature of the subject. Not all of these are accessible in print at the present time. The most notable, probably, were those of Prof. J. H. L. Vogt, of the University of Kristiania, Norway, and Prof. J. F. Kemp, of Columbia University, New York.

Prof. Vogt's contribution* (practically an independent paper of 45 printed pages) discusses principally: the original source of the heavy metals in ore-deposits; the relation between eruptive processes and the formation of ore-deposits, especially such as have been produced by eruptive action; the nature of the ore-solutions in vein-fissures; the relation between certain classes of vein-formation; differences of depth in the original position of epigenetic deposits; and the secondary alteration of deposits. The greatest emphasis is laid upon departments which Prof. Van Hise's paper avowedly neglected—particularly the direct action and "after-action" of intrusive magmas. This is a field in which Prof. Vogt is a recognized leader and authority; and the summary of his views given in this paper, though hastily prepared, and less completely fortified than he would desire, will be invaluable to American observers.

Prof. Kemp's paper,† though largely on the same subject as Prof. Vogt's, was different in method and purpose. The two contributions, taken together, restore in the discussion the equilibrium between igneous and aqueous factors, which the views of the previous contributors had somewhat disturbed, by laying greater weight upon the work of circulating solutions and humid reactions.

Just before this great discussion began, Prof. R. Beck, the successor at the Freiberg *Bergakademie* of the lamented Stelzner, issued the first part of his *Lehre von den Erzlagerstätten,* a splendid comprehensive treatise, in which the literature of this science is summarized. This summary enables us to measure the gain of the last year more precisely than we could otherwise do. Prof. Beck's

* "Problems in the Geology of Ore-Deposits." This paper is an exceedingly clear and able, though hastily prepared, summary of the author's views; and readers will find in it references to earlier treatises, in which those views are, as to some details, more elaborately stated and supported. These contributions are to be found, for the most part, in the *Zeitschrift für Praktische Geologie*, a periodical which no student of ore-deposits can afford to neglect. It is not too much to say that Prof. Vogt's writings, especially on the relations of the igneous rocks to the formation and deposition of ores, have well-nigh revolutionized the views of geologists with regard to that part of the field of inquiry.

† "The Rôle of Igneous Rocks in the Formation of Veins," (not yet published).

crowded pages and abundant illustrations in this beautiful book produce upon the reader the impression of a bewildering multiplicity of data. They hint that the science of ore-deposits has reached the stage, well-known in other sciences, in which the accumulation of observed facts has become too great to be longer tolerable. New types, new differences, have been discovered in marvelous number; and the time is ripe for the recognition of similarities and relationships, which shall simplify the complex problems and lighten the overwhelming load of disconnected materials. Toward that result, much progress has been recently made, and it is pleasant to know how heartily the world's great investigators in this department appreciate the work accomplished by Americans. Prof. Beck, in the preface to his great work, expresses regret that the highly important papers of Van Hise, Emmons and others reached him too late to be used in its preparation. In private correspondence, not only he, but other leading foreign authorities have expressed unstinted gratitude and praise for their American colleagues.

NOTES ON ELECTRO-CHEMISTRY.

By Charles F. Chandler.

Metallic Sodium and the Electrolytic Treatment of its Salts.

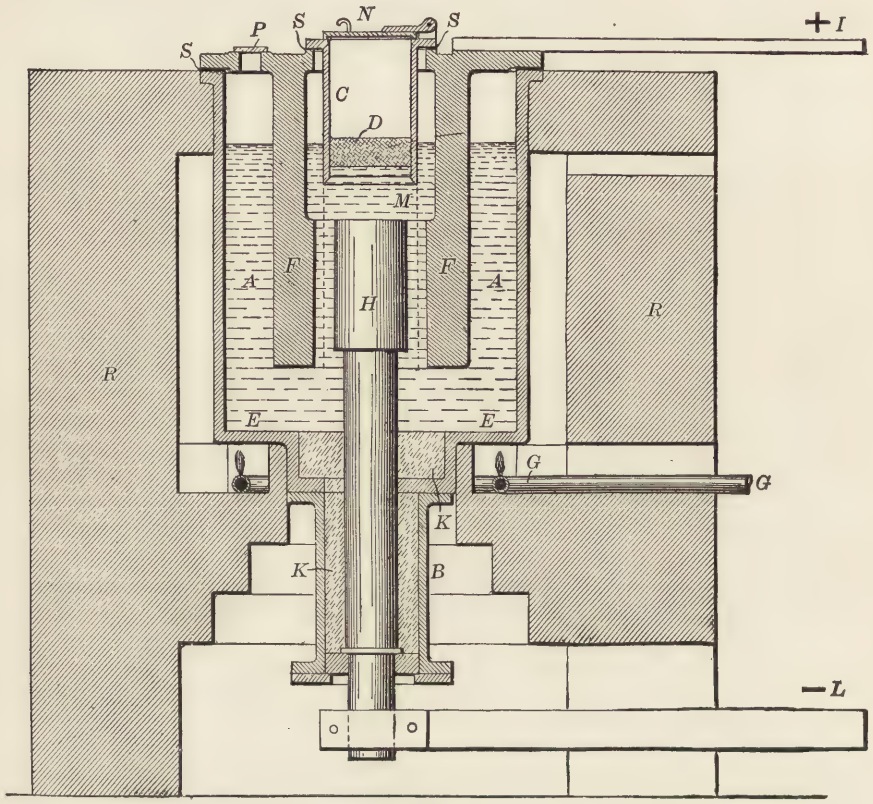
Sodium.—The ingenious process for the electrolytic extraction of the alkaline metals from their hydroxides as well as the process for the electrolytic decomposition of alkaline chlorides yielding sodium hydroxide and bleaching powder, were devised by Hamilton Young Castner, who was a pupil in the School of Mines, Columbia University, from 1875 until 1878, and whose early death in 1899 removed from the chemical field one whose ingenuity had done much for the general progress of the industry. Castner's first successful investigation was the process for the manufacture of metallic sodium and potassium from the fused hydroxides by the action of iron carbide according to the following reaction:

$$6NaOH+FeC_2=2Na_2CO_3+Fe+2Na+3H_2.$$

Practically there is no carbon monoxide produced although toward the close of the operation a small quantity is set free. This gas is unobjectionable when metallic sodium is being made, but in the case of metallic potassium it might result in the formation of the explosive, potassium carbonyl, $C_6(OK)_6$. The danger, however, may be avoided by the use of a slight excess of potassium hydroxide. Castner's sodium process was first put in operation near Birmingham, England. It was carried out in steel crucibles, each about 4 ft. deep, arranged in rows of 20 in a gas-fired furnace. The most favorable temperature was about 850°C. and 2·5 hours more or less were occupied in the operation. The sodium vapors produced were passed into condensers of sufficient size to receive two or three charges amounting in all to about 25 lb. of sodium. The yield was 95% of the theoretical amount and the crucibles were not materially injured as the temperature was comparatively low. The condensers were detached at the close of the operation and were then opened under refined petroleum of high test.* The cell is fully illustrated in Fig. 1. This process was patented in 1886 and, shortly after, an aluminum plant was estab-

* A modification of the original Castner apparatus, showing the method of water cooling the condenser and the lower part of the cell, is described and illustrated in The Mineral Industry, Vol. VIII., p. 681.—Editor of The Mineral Industry.

lished in connection with the Birmingham factory as, at that time, the only practicable process for the manufacture of aluminum was that invented by Deville, in which aluminum chloride was decomposed by metallic sodium. Up to the time that Castner's sodium process was in operation on a commercial scale, the high price of metallic sodium prepared from sodium carbonate (about $2 per lb.)



Section.

A, Fused caustic soda.
B, Cell support.
C, Condenser to collect the metallic sodium.
D, Metallic sodium.
E, Cell walls.
F, Anode.
G, Gas burner.
H, Cathode.
I, Conductor.
K, Insulation.
L, Conductor.
N, Cover to condenser.
P, Peep-sight for cell.
R, Brick-work.
S, Insulation.

FIG. 1.—THE CASTNER CELL FOR THE ELECTROLYTIC PRODUCTION OF METALLIC SODIUM FROM CAUSTIC SODA.

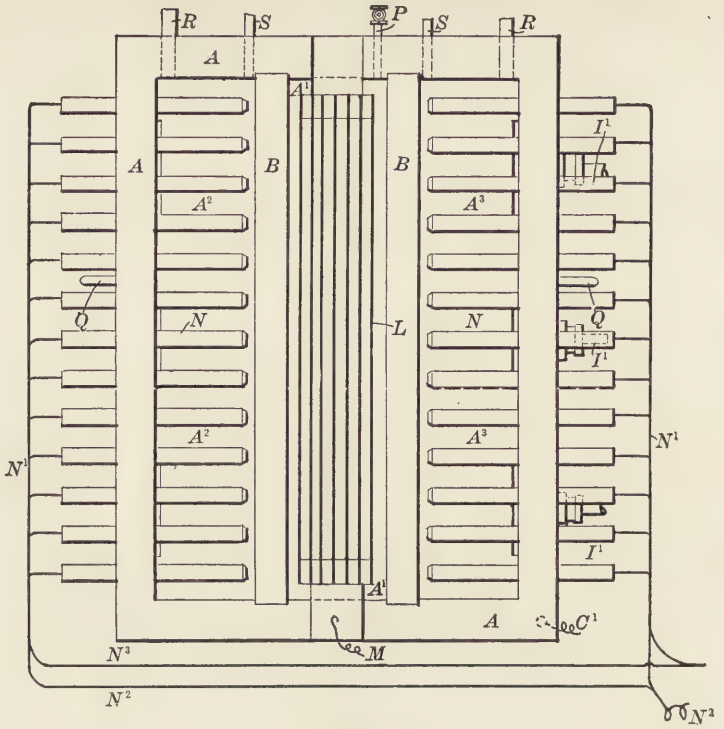
kept the price of aluminum at about $10 per lb.; the new process, however, reduced the cost of making metallic sodium so that aluminum could then be profitably sold at $5 per lb., half of the price that had previously prevailed. In consequence of this marked economy, the Birmingham works for a time practically monopolized the manufacture of sodium and aluminum. Later the elec-

trolytic process of Charles M. Hall displaced the sodium process for the production of aluminum. In Hall's process, the alumina is dissolved in a melted bath of the double fluoride of sodium and aluminum and subsequently electrolyzed. This process was carried out first at Kensington, Pa., and later at Niagara Falls, N. Y., where the metal is produced at so low a cost as to make the price for equal volume on a par with that of copper. The economy in the low cost of the Hall process practically supplanted the sodium process for producing aluminum, but owing to the new applications for metallic sodium there is still a moderate market for it, and it continues to be manufactured on a moderate scale.

In 1890 Castner devised an electrolytic process for the decomposition of sodium hydroxide, and patented it in 1891. Since then it has been used at Niagara Falls, N. Y., in England and on the Continent. The process is continuous and extremely simple. It is carried out in iron pots, the caustic soda being replaced as it decomposed, and the metallic sodium being ladled off from time to time as it is formed. A part of the metallic sodium produced is sold, but much of it is converted into other compounds at the factory. The most important of the sodium compounds are, sodium peroxide, which has an extensive application for bleaching purposes, and sodium cyanide, which is used for the extraction of gold from poor ores. The advantage of sodium in the preparation of the cyanide salt is due to the fact that in the old process of manufacturing potassium cyanide by the fusion of potassium ferrocyanide and potassium carbonate, a very impure product resulted which contained potassium carbonate, potassium cyanate and other objectionable constituents. By the substitution of metallic sodium for potassium carbonate, a product was obtained which consists entirely of potassium and sodium cyanides. Metallic sodium also finds an important application in the preparation of coal tar products and other similar compounds.

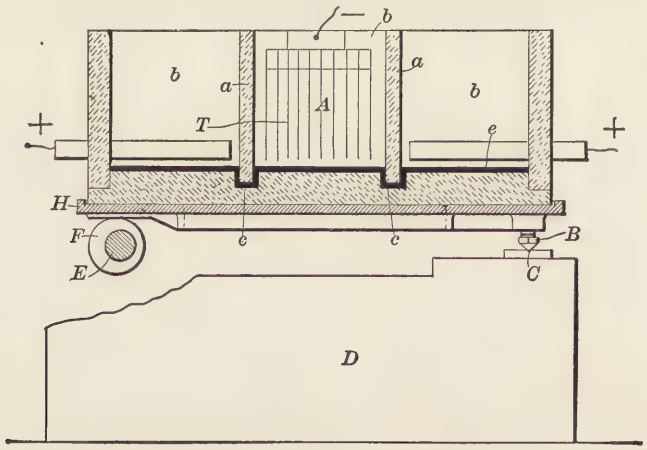
Sodium Cyanide.—In 1894 Castner devised the process for the conversion of metallic sodium into sodium cyanide by causing the molten metal to percolate in a fine state of division through heated carbon or hydrocarbon vapor in the presence of a current of free nitrogen.

Caustic Soda and Chlorine.—Numerous processes have been developed for the electrolysis of a solution of common salt with the production of caustic soda and chlorine, but difficulties have arisen from the reaction of the chlorine upon the caustic soda which resulted in the formation of hypochlorites and chlorates. Furthermore, the caustic soda formed was never free from sodium chloride. All these difficulties were completely overcome by the Castner process in which the usual porous diaphragm is avoided, and a moving cathode of quicksilver is used in its place which absorbs the metallic sodium as fast as it is produced, and removes it at once from the decomposing cell to a neighboring one where the sodium is withdrawn electrolytically and converted into sodium hydroxide. The operation is accomplished in what is known as the "tipping" cell, which is so arranged that once a minute it is rocked upon its support just enough to cause the mercury cathode in the bottom to flow back and forth under the partition to and from the neighboring cell where the sodium hydroxide is produced



Plan.

A, *A*¹, *A*², *A*³, *B*, Cathode frame and connections.
*C*¹, Conductor to cathode frame.
L, Cathodes.
*M*¹, Conductor to cathodes.
N, Anode.
*N*¹, *N*², *N*³, Conductor to anodes.
P, *Q*, *R*, *S*, Pipes for passage of solution and mercury.



Section.

A, Cathodes.
a, Cell walls.
b, *b*, *b*, Adjoining compartments.
c, Mercury passage under cell walls.
e, Mercury.
B, Screw for adjustment.
C, Base plate.
D, Foundation.
E, Rotating shaft.
F, Eccentric to impart oscillating motion.
H, Tank frame.

FIG. 2.—THE CASTNER DECOMPOSING CELL FOR THE ELECTROLYSIS OF SALT SOLUTIONS.

free from chlorine. The metallic sodium never exceeds more than 0·2% of the mercury, and, consequently, there is very little loss from the recombination of sodium and chlorine in the decomposing cell. The construction and arrangement of the cell is shown in full detail in Fig. 2.

An important adjunct to the tipping cell is Castner's graphitized anode. In the ordinary carbon anodes such as have been previously employed, it was found that the combined action of the chlorine and other substances resulting from the electrolysis of sodium chloride, together with the chemical reactions which occurred at or near the surface, disintegrated them very rapidly. By converting the anodes after they have been shaped and baked, into the graphitic form they are of much greater durability and the graphitizing process has been regularly employed on a large scale for this purpose. Other modifications and improvements in the details of the construction of the tipping cells have been made which facilitate the production and have increased the efficiency of the process. The Castner process yields pure caustic soda and pure chlorine, and has been in successful operation for several years in England, on the Continent, and at Niagara Falls, N. Y. At the last named locality the company now using it is greatly extending its plant.

Electrical Manufacture of Phosphorus.

On account of its simplicity the electric process for the production of phosphorus seems destined to displace entirely the old processes which have been so long in use. The new process depends upon the use of silica in place of sulphuric acid for removing the base from the calcium phosphate used, this being rendered possible by the intense heat of the electric arc.

The old process for the manufacture of phosphorus was based upon the following reactions which occurred when bone ash, sulphuric acid and carbon were combined:

1. $Ca_3(PO_4)_2+2H_2SO_4=2CaSO_4+CaH_4(PO_4)_2$.
2. $CaH_4(PO_4)_2=Ca(PO_3)_2+2H_2O$.
3. $3Ca(PO_3)_2+10C=Ca_3(PO_4)_2+10CO+4P$.

The new electric process uses cheap mineral phosphate, sand, and coke in about the following proportion: calcium phosphate, 100; sand, 50; coke, 50. The reaction that occurs is exemplified by the following equation:

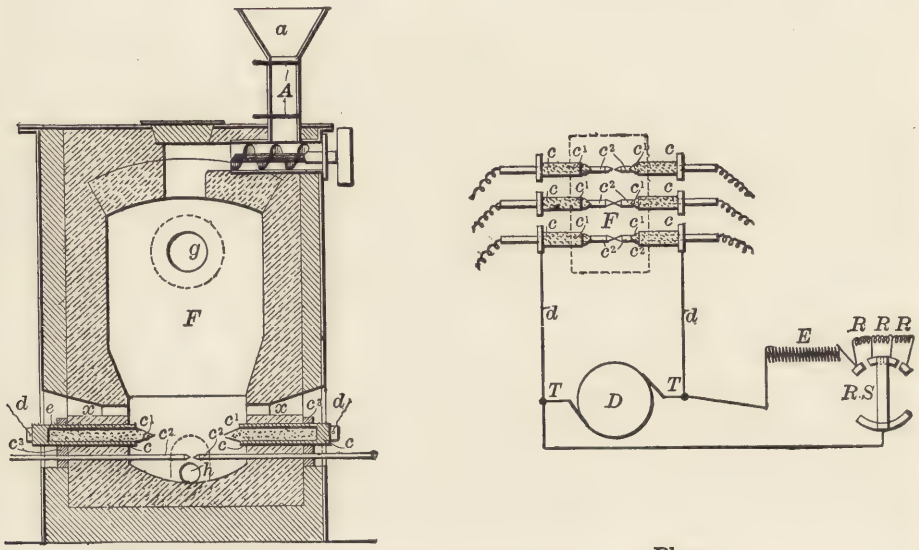
$$Ca_3(PO_4)_2+3SiO_2+5C=3CaSiO_3+5CO+2P.$$

This chemical change was first suggested by Woehler, but was impracticable at that time on account of the high temperature required. At present the electric production of phosphorus is on a profitable basis, and the works of Readman & Parker at Wednesfield, England, produces the greater part of the entire world's production; 86% of the phosphorus is recovered and the residue, calcium silicate, is withdrawn as a fused slag. Fig. 3 gives the plan and vertical section of Readman and Parker's electric furnace. The Gold & Silver Refining Co., of Frankfort, has an electric furnace for the manufacture of phosphorus,

and this element is manufactured also at Griesheim, Germany, and at Niagara Falls, N. Y. (United Alkali Co.)—Fig. 4 shows the vertical section of the electric furnace for phosphorus that is used by the Deutsche gold und silber Scheideanstalt at Frankfort.

Salts of the Rare Earths.

The most beautiful and interesting case of chemical preparations at the Paris Exposition of 1900 was exhibited by Chenal Douilhet et Cie, Paris. Besides a hundred or more specimens of very interesting chemical preparations, both inorganic and organic, which had never been exhibited before, it contained a



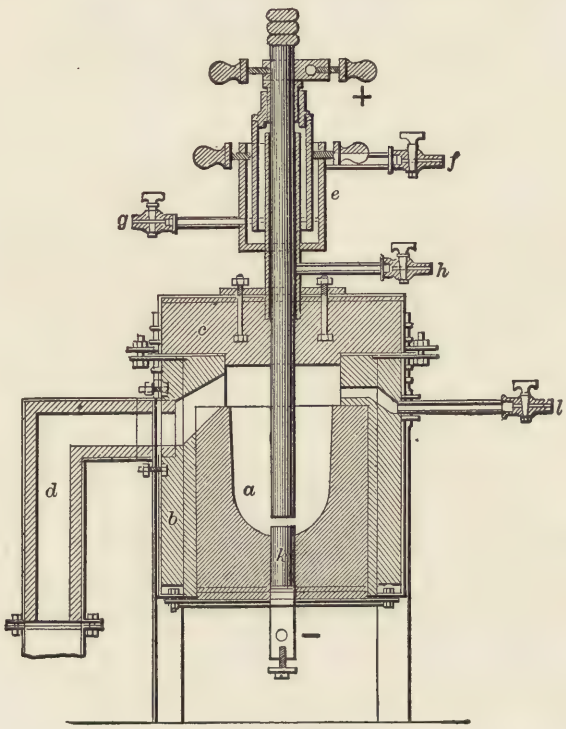
Vertical Section. Plan.

a, Hopper.
A, Feed to screw conveyor.
c, Electrode cover.
*c*¹, Electrode.
*c*², Bars.
*c*³, Insulation.
d, Conductor.
F, Furnace body.
g, Exit for phosphorus vapors.
h, Exit for slag.
D, *T*, *RS*, *R* and *E*, Dynamo and electrical attachments.

Fig. 3.—Readman and Parker's Electric Furnace for Phosphorus.

remarkable collection of compounds of the rare earth metals; thorium, cerium, lanthanum, praseodymium, neodymium, samarium, yttrium and gadolinium. The salts were in the form of protoxides, peroxides, nitrates, sulphates, platinocyanides and carbides. The specimens were beautifully crystallized and were usually in amounts of 2 kg. each, although in a few cases they were as small as 250 g., and in the platinocyanides of cerium and gadolinium they weighed but 100 g. each. This was more than offset by the 15 kg. lots of beautiful deep pink crystals of neodymium-ammonium nitrate, neodymium-magnesium nitrate, cerium-ammonium nitrate, lanthanum-ammonium nitrate and magnesium-ammonium nitrate. These rare earth compounds were obtained by

Chenal Douilhet et Cie from working up 50,000 kg. of monazite sand from North Carolina and Brazil for the manufacture of thorium oxides for Welsbach gas-light mantles. They also obtained the following quantities of other rare earth oxides: ceria, 20%; lanthania, 15%; thoria, 4·6%; neodymia, 3 to 4%; yttria and yttria earths, 1·5%; praseodymia, 1%; samaria, 0·5 to 1%; gadolinia, 0·5%. The yttria earths not yet separated contained holmia, terbia, erbia, ytterbia, thulia, and dysprosia. The development of the thoria industry



Vertical Section.

a, Furnace crucible.
b, Wall.
c, Cover.
d, Flue to condenser.
e, *g*, *h*, Water cooling system.
f, Gas inlet.
k, Electrode.
l, Gas exit.

FIG. 4.—ELECTRIC FURNACE FOR PHOSPHORUS USED AT THE DEUTSCHE GOLD UND SILBER SCHEIDEANSTALT.

is shown by the fall in prices, which are quoted as follows: In 1893, 1 kg. of thoria nitrate sold for 2,000 fr. in 1894 and 1895 at 1,500 fr., in 1896 at 1,000 fr., 1897 to 1898, at 80 fr., and finally in 1900 at 50 fr.

ARTIFICIAL GRAPHITE.

In the manufacture of carborundum it was noticed by Mr. E. G. Acheson, who invented the process, that a layer of graphite was formed immediately in

contact with the core in the hottest part of the electric furnace, and, in a study of the formation of this substance, it was shown that the graphite resulted from the decomposition of a carbide that had been previously formed. On experimenting with this interesting product it was found that pure carbon is not converted into graphite by electrical heat alone, but that carborundum, which is silicon carbide, when sufficiently heated loses all its silicon and leaves its carbon as soft, pure graphite. In addition, Mr. Acheson found that carbon containing small quantities of certain metallic oxides or salts was converted into graphite by electrical heat. A satisfactory mixture in this case consists of 97 parts of amorphous carbon as powdered coke or charcoal, and 3 parts of iron oxide. This mixture may be molded into articles, and subsequently converted into graphite.

When the electrodes of the electric furnace are 16 ft. apart, and the connecting cylinder of carbon containing the articles to be graphitized is 20 in. in diameter, the current begins at about 150 volts and 300 amperes, and, as the graphite is formed the mass becomes a better conductor of electricity, and its resistance falls, consequently the voltage of the current can be lowered and the amperage increased until the graphitization is complete. At the end of the operation the voltage may be 100 and the amperage 7,000. This process is now in full operation at Niagara Falls, N. Y.

Electrolytic Lithium.

The electrolytic separation of metals from anhydrous compounds rendered fluid by heat has long been known and practiced. Sir Humphrey Davy used the electric current to fuse and electrolyze potassium and sodium hydroxides in 1807, thereby demonstrating the existence of these metals. St. Claire-Deville electrolyzed fused cryolite and obtained aluminum, and Bunsen obtained magnesium and lithium from their fused chlorides. Charles M. Hall utilized a molten bath of mixed chlorides for a solvent which dissolved alumina in large quantities and furnished a solution from which the electric current readily extracted metallic aluminum, the heat generated by the current maintaining the bath in fusion and fresh alumina being added as required to replenish its proper portion in the bath. The success of this "anhydrous" solvent is demonstrated by the immense plant at Niagara Falls, N. Y., which produces about 20,000 lb. of aluminum daily. The latest advance in this line is the discovery of Dr. L. Kahlenberg, of the University of Wisconsin, who has found in pyridine, an anhydrous solvent for lithium chloride which not only dissolves it readily in the cold, but produces a solution that is easily decomposed by the electric current at ordinary temperatures with the deposition of pure lithium. The great advantage which may result from the use of these anhydrous solvents for the preparation of baths of metallic salts to be electrolyzed can readily be appreciated. By their use the difficulties of secondary reactions which take place in the presence of water are avoided, and the many troubles often experienced with fused baths are overcome.

Electrical Manufacture of Ozone.

Ozone is now being produced with the aid of electricity, and it is finding important applications in several chemical industries. At the works of the Société Anglo-Française des Parfums Perfectionnes at Courbevoie, near Paris, it is very extensively used as an oxidizer in the manufacture of artificial perfumes, etc. About 150 E. H. P. are required to produce 8 kg. of available oxygen in the form of ozone, which corresponds approximately to 25 kg. ozone per hour. Ozone is cheaper as an oxidizer than potassium permanganate, and it has the additional advantage of simpler reactions, and of leaving no objectionable by-products. Ozone is used for a variety of purposes, especially for the manufacture of engenol, vanillin, safrol (oil of sassafras), and piperonal (heliotripine). The development of the industry is shown by the reduction in the prices of these products. Four years ago vanillin sold for 630 fr. per kilo; its present price is about 90 fr. In 1870 heliotripine sold for 7,000 m. per kilo; its present price is about 30 m.

According to M. M. Otto,* the preparation of ozone has been greatly simplified by the device which does away with dielectrics, thus enabling a more durable construction of the generators than would be possible with their use. The best types of generators may be divided into two classes: (*a*) Rotating generators with moving electrodes; (*b*) rotating generators with commutators. A simple and effective apparatus of the first class consists of two metallic discs from which a portion of the metal has been cut out in the form of sectors. These discs serve as conductors and are placed on an axis and connected with the opposite poles of a transformer of high potential. The adjacent surface of the discs are supplied with metallic blades. One of the conductors is fixed, while the other being rotated causes a flow of current whenever the arms of the conductors are in parallel positions and breaks the current as the arms recede. In the second class of generators, the fundamental principle of construction is the same as in the first, but the breaking of the current is accomplished by means of moving commutators. A typical apparatus of this kind consists of two series of electrodes carefully insulated and fastened to a strong framework of iron. The electrodes are placed at such distances apart that the electric current cannot pass directly between them. Equidistant from each of the electrodes is a revolving conductor, which acts as a commutator and is of similar design to the electrodes described in the apparatus of the first class.

For determining ozone quantitatively, Otto advocates the potassium iodide method. Ozone reacts on an aqueous solution of potassium iodide according to the formula:

$$2KI+O_3+H_2O=2KOH+I_2+O_2.$$

The iodine set free combines immediately with the potassium hydrate to form potassium iodate and periodate. However, in the presence of an excess of sulphuric acid, the potassium is combined with the latter and the iodine, remaining free, can be estimated with sodium hyposulphite. Care must be taken against

* *Compte Rendu, Société des Ingénieurs Civils*, February, 1900.

the use of too strong acid which also decomposes the iodide. In the presence of sulphuric acid, the reaction may take place according to either of the following equations:

$$(1)\ 2KI+O_3+H_2SO_4=K_2SO_4+I_2+O_2+H_2O.$$
$$(2)\ 2KI+O_3+2H_2SO_4=2KHSO_4+I_2+O_2+H_2O.$$

According to the first equation 49 parts, and according to the second, 98 parts of sulphuric acid are required to complete the reaction. In the first case, the free iodine is gradually absorbed while in the second it is precipitated, showing that sufficient acid should be added to allow the formation of the primary salt. When the solution is titrated with sodium hyposulphite the following reaction takes place:

$$2Na_2S_2O_3+I_2=2NaI+Na_2S_4O_6.$$

The titrating solution when made up of 6·583 g. of hyposulphite per liter will show 1 mg. of ozone for each cubic centimeter required to effect the reaction.

NOTES ON THE CONCENTRATION OF FINELY CRUSHED ORES.

By Walter McDermott.

In the following notes on some modifications of plant to concentrate finely crushed ores, I discuss the principles involved in the action of certain types of machines, but do not refer to special makes. I was a joint inventor of the Frue vanner and was associated for many years with its introduction, and this explanation may save misunderstanding. At the present time there are many makes of shaking traveling belts, and I shall refer to this class hereafter under the name of "vanner." The well-known Wilfley table also is one of a number of similar concentrators, working on the principle of a "throw" or "jerk" of the heavier particles, and this class I shall refer to as that of "jerking table." The Bilharz side-inclined bumping belt has also its variations, and this class I designate as "percussive belt." Belts having an end-incline in place of side-incline, and a percussive motion, were occasionally used in the past, but have no present importance; consequently the term "percussive belt" may be limited to the side-inclined class. "Bumping tables" of the class used in the western United States are by this title distinguished from the Rittinger table, in which the direction of inclination is at right angles to the line of motion.

As the term "fine crushing" is relative, for the present purposes, it may be taken as referring to a pulp which will pass at least a wire mesh of 20 holes to the linear inch or 400 holes to the square inch, and, therefore, comes within the general stamp mill practice; but many of the points to be raised are applicable chiefly to a pulp passing 30 or even 40 mesh. The ore to be treated must modify the choice of a plant according to the requisite of making (1) headings and tailings, or (2) an intermediate product in addition. The shaking belt machines and the bumping tables are not adapted to the second class of work; while the jerking tables, percussive belts, Rittinger tables and revolving buddles must usually re-treat an unnecessary middle product in order to give close results on the first class of work. It is a matter of notoriety that few millmen are capable of working out the best combinations of machinery for a given ore, or of making methodical tests on which reliable conclusions may be made. A new machine with claims for a variety of work as well as great quantity, naturally appeals to the desire for improvement in results, and it takes a long time to establish the fact that it needs to be handled with as much discretion and is as limited in its application, as the older types. No better evidence of this fact is required than the handsome testimonials which every machine liberally receives on its early introduction. Millmen who have given such testimonials do not easily or quickly admit their hastiness.

Confining these notes to ores suitable to Class 1, the first point on which authorities differ is that of classification. On this subject it is absolutely impossible to lay down a universal law based upon theoretical considerations of concentration; because on different types of fine concentrators, the relative effects of mass are quite different. This is shown at once by the fact that a shaking belt will not take up with the concentrates a silver coin, which nevertheless has mass, specific gravity, and small surface exposed to the running water, all in its favor under ordinary concentrating conditions. The coin, however, would immediately appear in the concentrates if it were put on a jerking table, a bumping table, a percussive belt, revolving buddle, or Rittinger table. As would be naturally inferred, these last-named machines are not so well adapted to treat an unclassified pulp as is the vanner. Experience of many years on a great variety of ores proves beyond question that there is generally no advantage, and often a distinct disadvantage in sizing pulp below 40 mesh for a vanner. It has been to me at times a source of amusement to see the effect of the discovery made by students fresh from the study of the immutable laws of concentration, that in many mills, shaking belts were running without previous classification. There was an epidemic of this discovery in the Transvaal a few years ago which led to the appointment of a committee by the Transvaal Chamber of Mines. Careful experiments were made on classified and unclassified pulp, and the committee finally reported against classification. In a pamphlet* that I wrote some 24 years ago on the action of the vanner is the following: "It is not necessary that the material on which the belt works should consist of the finest slimes; but, of course, as with all dressing machinery, the more uniform the size of the ore the better the results obtained." This was written under the influence of ideas originating with other types of machines, and naturally without the experience subsequently obtained from extensive working. The fact is that the coarser grit on a shaking belt checks the flow of slimes down the incline, effects a more perfect settling of the finest particles of mineral, and does not in the least interfere with the delivery of the finest particles to the concentrate tank, by the travel of the belt. There is no loss of the coarser particles of mineral, and a given number of machines will treat more ore than if the pulp were classified.

On the other hand, with the other types of slime concentrators, experience has fully established the necessity for classification to get the best results. It may be shown that in most mills it is a decided advantage to avoid classification if possible for the following reasons: While hydraulic classifiers are simple enough, they introduce an element for regulation, and an occasional cause of stoppage. They consume water, an important item in places. They dilute the pulp and thus tend to diminish capacity of concentrators; and finally they wash off in a very dilute condition the finest slime mineral, which is the most difficult to save, requiring additional careful settling before treatment. It is a fact that some millmen, after installing a classification plant, have allowed this slime overflow to go to waste and then have congratulated themselves because their tailings had been lowered in value from this separate running away of the finest mineral

* The Frue Vanning Machine.

which had previously gone over their concentrators and in part appeared in their tailings. A further practical illustration of the position here taken is afforded by experience at the Cornish tin mines. The ores require fine crushing, and the stamps make much slime mineral. Two years ago a series of experiments, lasting several months, was made on percussive belts and revolving buddles with classification; on vanners without classification; and later with jerking tables. As a result vanners were adopted in the principal mills of the district, without classification of pulp, and with a single treatment. In the case of tin-stone, an important element in the choice of machinery is the advantage of making a clean concentrate for smelting without intermediate product, in addition to the necessary close saving of the finest slime mineral.

Having mentioned the objections to classification in many cases, and the proved absence of any necessity for it on a number of ores, it is worth while to specify when and how it may be used to advantage, still confining the consideration to ores requiring no middlings product. A gold or silver ore containing rich brittle minerals productive of loss in slimes, cannot be expected to yield a perfectly satisfactory result by a single treatment on any type of machine made, or likely to be made. There will certainly be loss of fine slime mineral. To classify is only to treat separately the coarser particles which in themselves offer no difficulty, and to accentuate the real difficulty in the finest size as previously mentioned. The loss which occurs in any concentrator is partly unavoidable, and partly accidental. The accidental loss may be diminished by putting the tailings over a second similar machine, which proves that the particles escaping the first machine did not happen to settle but were capable of it. Even in comparatively imperfect types of concentrators it is surprising how exceedingly fine many of the particles of mineral are which go into the concentrates with the coarser particles. Experience on all varieties of the difficult ore under consideration has shown the fact that the shaking belt type of machine affords the best chance for perfect settling of the finest slime mineral, and the reasons are quite obvious. The steady, shaking motion, slow current of water, and length of surface allowed, are all most favorable conditions for settling, while the belt surface affords a perfect protection to the finest slime mineral when once settled on it, undisturbed by the shake. In the bumping tables, Rittinger tables, jerking tables, as also, partly in the percussive belts, a fine particle of mineral once settled on the surface has to travel a varying distance by a succession of jumps, exposed during these movements to the descending flow of pulp or water, and so incurring the risk of loss which may be termed accidental. Again, relatively larger quantities of water are usually necessary to keep back the waste; or a steeper inclination of table is made which means a more rapid current. Further, the production of a middlings product, which needs re-treatment, in itself involves an extra loss. How, then, can a double treatment be best effected on vanners so as to reduce the accidental loss from a single treatment? It is not advisable to put the tailings of one machine over an equal sized one; unless the excess of wash water from the first is removed from the tailings by a settling box; but the pulp can be spread over two similar belts or over one wider one. Another alternative, however, calls for particular mention. If the tailings be

vanned by hand it will be found that all the loss is in excessively fine mineral; and if all the coarser particles of rock could be removed, a small and partially concentrated tailings product would remain. So that a classification, which was unnecessary or objectionable on the original pulp, might be really desirable on the tailings for re-treatment. The reduced quantity of fines to be treated a second time requires a relatively small number of vanners, instead of a duplication of the first set. If the first tailings are run through a hydraulic sizer the coarser discharge of this would run to waste, the overflow passing to a large spitzkasten for thickening the pulp of slime to a proper consistency for the second vanner. By this arrangement the slime mineral, which is the part subject to loss, has been over two machines, and has had a double chance of being saved; for much of it which escapes the first belt is not any finer or more difficult to save than some of that already caught. It is evident that the function of classification in this application to the tailings is quite different to that of sizing before treatment; and it secures first a treatment on belts with the grit (which it has been shown above is advantageous); and secondly a treatment when free from the coarser sand and in a reduced quantity which allows of a slow, careful working. If a lower grade concentrate is not objected to, and closest saving not a chief object, canvas tables may be used for the second treatment; and if these are in sufficient numbers the settling by spitzkasten may be dispensed with. More perfect still if practicable would be the use of a fine screen in place of classification as referred to later in these notes.

In some cases, the fear of losses in slimes, losses that may be reduced by variations in ordinary methods, determines the adoption of roll mills with jigs and regrinding appliances on material in which the state of division of the mineral better adapts the ore to a direct crushing by stamps. In the ordinary jig mills there is a great complication of machinery, and a great wear and tear of screens, elevators, and launders; with more wearing and sliming of mineral by attrition than is generally known. Again, the great volume of water that is needed for screening and classification, aggravates the difficulty of dealing with the slimes and increases the loss. The machines used for regrinding the jig tailings are subject to greater wear than stamps and are more liable to serious stoppages. Further, with stamps there is a blessed calm in the mind of a manager which no other means of crushing can insure. So that for ores in which the mineral is not too massive, there are excellent reasons for the use of stamps with low discharge and coarse screens, followed by special precautions to reduce the loss in the slimes. In Utah, some very heavily mineralized lead ores have been stamped successfully and treated twice by shaking belts. By taking the heaviest mineral out on jerking tables, with a double treatment of the fines on vanners, a simple, cheap running plant with the highest efficiency is obtained. It is possible with coarse screens on the battery to deliver a jig product in addition, when finer crushing is not necessary to free the mineral.

Considering the objections already set out against classification, and the additional fact that, after all, it is a division into equal falling and not equal sized particles, it would appear that a great advantage would be gained if screening could be carried down to a much finer mesh than is practicable by the usual sys-

tem. A suggested method for the accomplishment of this and one which might be found even more effective than the usual trommels on some of the coarser sizes also, is the following: The vibrometer, a flat inclined screen slung on wire ropes and operated by a suspended rotating weight out of balance—a most effective machine—if suspended in water within a pointed tank giving a continuous discharge below, would have the pulp discharged on to it subjected both to the descending current through the screen and to the rapid vibratory motion for forward movement of the coarser particles. These latter would empty by a lip into a second pointed division of the tank fitted with an extra water supply near its discharge in order to avoid the downward current. In this way no extra wash water would be employed in the finer division, and, working under water, fine holes with reduced wear would be possible in the screen, which would be a plane surface easily renewable. An alternative modification would be to have the inclined submerged screen surface fixed, and a slight, rapid pulsation of the water produced from below by the usual plunger arrangement. A system of this character, following the stamps, with jigs and jerking tables, seems well adapted to some of the Broken Hill mixed sulphides that need finer crushing than in ordinary jig mills, and require a close separation of two minerals. It would have great advantages over the usual jig mill with its regrinding of tailings on lead or copper ores, or on gold bearing pyrites, as well as in cases where the mineral is disseminated throughout the gangue and also is in part massive. As already pointed out, the wear and tear of the usual machinery, and the sliming from actual attrition which takes place in the many handlings, together with the difficulties involved from the great dilution of pulp by screening and classification water, constitute actual disadvantages which would be apparent in a comparison of results on a more direct and simpler method of treatment. It is of course not contended that the jig mills as usually employed can be generally replaced by stamps as suggested; but it is undoubtedly a fact that in some cases a mere traditional fear of sliming mineral has driven millmen into losses and expenses in other directions much more difficult to correct. Millmen are more willing to try new machines than to attempt re-arrangement of methods; but in working special ores there is far less room for improvement in the former case than in the latter.

Concentration by Oil.—Quite recently a method of concentration by the mixture of a thick oil with the pulp has been perfected and introduced in at least one instance on a practical working scale of 50 tons of ore per day. It has been known that oil and greases have a selective action for certain substances, and attempts have been made in the past to utilize this fact. In South Africa, a shaking table covered with thick grease is used successfully to pick up diamonds from a flowing stream of tailings below the circular washers. The diamonds stick on the grease surface, while the rocky particles roll over it unchecked.

The Elmore concentration process* was evolved as a result of experiments on the tailings of a German jig and Luhrig table plant, which in itself was a failure.

* Reference should be made to the discussion of this important process by Prof. R. H. Richards in "Review of the Literature of Ore Dressing during 1900," given elsewhere in this volume.

It consists in the agitation of thick residual oil with the flowing stream of pulp in a cylinder carrying a helical trough, across which are occasional baffle plates to turn over the pulp. The pulp and intermingled oil drop into a pointed box, from the top of which the oil overflows, and from the bottom of which the water and sand discharge. The oil, with the mineral it has absorbed, passes to a centrifugal separator in which the mineral is thrown out against the revolving basket; the oil overflows at the top and is returned by a pump to re-circulate with the stream of pulp in the mixing cylinder. In practice, for close saving, it has been found advisable to use three mixing cylinders, so that the sand from the first receives a second and third addition of oil in the lower cylinders; and a second centrifugal machine is used below the first to get a more perfect extraction of oil from the concentrates; but the whole process is continuous and automatic, except for the discharge of the final concentrates from the centrifugals, which involves very little labor.

Oil has a faculty of attaching itself to bright metallic particles and to nearly all sulphide surfaces, but not to all of either of these two classes of material. For instance it does not attach to aluminum and it has little effect on zinc blende. The following materials seem well adapted to a commercial close saving: Metallic gold, silver, copper, copper and iron pyrites, bornite, gray copper, brittle and ruby silver, tellurides, cinnabar, stibnite, molybdenite, graphite, sulphur and galena.

As the determining factor is the conveniently called "affinity" between the oil and the mineral to be saved, and as the oil if not agitated will float on the water of the pulp, it is evident that specific gravity does not affect the operation. As a consequence, copper pyrites may be extracted from magnetite or heavy spar by the process; a separation that is impossible by water concentration; and it is also possible to separate successfully floating slimes of brittle mineral. There would appear to be, therefore, a distinct and profitable field for an oil process outside the limitations of ordinary concentration, either as an adjunct or substitute when treating ores which necessarily involves a loss of slime mineral.

The plant is simple in character and adjustment, and uses only the amount of water needed in the ordinary stamping of ores. Where water is scarce it may be settled and used over again. The cost of operating may be assumed as not in excess of that of a stamp and vanner plant, plus the loss of oil and the cost of royalty charged on the process. The consumption of oil seems as far as yet determined to vary from 1·25 to 2·5 gal. per ton of ore; it is very cheap, being the residuum of oil refineries. As a complete separation of the oil from the concentrates is not obtainable, the loss of oil will vary with the percentage of mineral in the ore. The small quantity of oil left in the product—from 2 to 4%—will not interfere with the usual methods of dealing with concentrates, and may even be of service in briquetting them for smelting, or in direct smelting.

THE FILTER PRESS TREATMENT OF SLIME IN WESTERN AUSTRALIA.

By J. K. Wilson.

From the early days of Kalgoorlie it was apparent to those who had to do with the metallurgical treatment of the ore that a rapid and effective method of dealing with slime would form a most important factor in the future success of the fields.

The large amount of calcareous and argillaceous matter contained in the ores—more especially in those of the oxidized zone—and the consequent high percentage of slime produced in milling, coupled with the fact that much of the gold existed in an almost infinitesimally fine state of division and was practically unrecoverable by amalgamation methods, rendered it absolutely imperative that some scheme should be devised whereby the immense heaps of rich slime which were accumulating at the various mines should be brought to profitable account. As time advanced and a more intimate knowledge of the characteristics of the ore showed that fine crushing was even more necessary in connection with the treatment of the sulphides than with the oxidized ore, the importance of slime treatment was correspondingly enhanced.

The conditions under which the work was to be carried out were peculiar, and presented considerable difficulties.

(1) As already indicated, the quantity of slime produced at the different mills was very great. The average amount of sands amenable to percolation saved at the Lake View, Ivanhoe and Horseshoe mines was about 50% of the total ore crushed; *i.e.*, in crushing through 30-mesh screens one half of the ore was reduced to such a fine state of division that it could not be dealt with in the ordinary cyanide plants; while where pan amalgamation was in vogue, as at the Great Boulder, almost the whole of the battery product was in the form of slime.

(2) The high value of this slime—from 8 dwt. to 1 oz. and even more—while permitting of a fairly costly treatment, called for one not only capable of dealing with large bodies of slime but also of extracting the gold therefrom quickly.

(3) The scarcity of water on the fields rendered it desirable that the work should be carried out in such a manner as to allow the return of water to the mill with as little loss by evaporation or waste as possible.

Filter pressing was first introduced by the Lake View Co., in the early part of 1898, and although subsequent decantation experiments were carried out on a large scale by several of the leading companies, it was found that the time occupied in thoroughly washing the large bodies of rich slime by decantation was too great as compared with the rapid manner in which this could be effected by means of filter presses, and although the working cost of pressing is considerably higher than decanting, it has now been universally adopted on the fields.

The design and arrangement of the various plants at Kalgoorlie naturally vary according to the nature of the ore, or the ideas of the engineer or metallurgist in charge. Broadly speaking, however, they may be divided into two classes, *viz.*, single pressing and double pressing plants.

Single Pressing.—This method is applicable for the treatment of (*a*) slime containing gold so readily soluble that it may be dissolved in the press, and (*b*) slime from a dry-crushed ore or one that has been lying exposed to the sun and the weather and contains but little moisture. At Kalgoorlie single pressing is carried out in two ways. (1) Where the gold is brought into solution in the presses themselves, as at the Lake View and Golden Horseshoe mines. (2) Where it is dissolved in agitation vats prior to entering the presses—the press being used merely as a filtering medium, as at the Brownhill, Ivanhoe and Great Boulder mines.

Under the first subdivison, where the gold is dissolved in the presses themselves, the method was first introduced by the Lake View Consols and has been worked by them for some two years with satisfactory results. The plant consists of 16 Dehne complete-extraction frame-presses—the frames of which range from 2·5 in. to 3 in. in width; two montejus pressure tanks; two Excelsior (gravitation) filters for clearing the liquors before entering the precipitation boxes and a 4-drill air compressor, together with necessary pumps, pipes, etc. The plant is capable of treating about 4,000 tons of slime a month at a cost of treatment of about $1·50 per ton.

The modus operandi is as follows: The slime on leaving the distributing vats, where the bulk of the sand has been settled, is passed through a series of pointed boxes, or spitzkasten, and any sand which may have escaped the distributors is caught. The true slime, 98% of which will pass a 150-mesh screen, flows into settling tanks and the excess of muddy water is drawn off and pumped through two presses set apart for this purpose. When these presses become full of slime, they are dealt with in the same manner as the others, the water being returned to the mill. As the slime settles in the tanks it is run out from the bottom into the montejus tank and forced into presses by means of compressed air—the pressure required being from 30 to 60 lb. per sq. in., according to the thickness of the cake. The clear water is returned to the battery and a cyanide solution containing about 0·2% KCy is pumped through the press; compressed air also being forced through the charge at intervals of five minutes or so until the gold is dissolved. The wash, either of weaker cyanide solution or

water then follows and the charge is dried to a certain extent with compressed air, after which the press is opened and discharged. It is found that all the gold passes into solution in about 20 minutes, and the whole operation of treatment is completed in about two hours.

It is a remarkable fact that with certain of the Kalgoorlie ores no better extraction is obtained by a prior agitation for 3 or 4 hours in vats, than that effected in the press with aërations as described. It is also a noticeable feature of this method that whenever air has been forced through the charge the exuding liquors are of increased gold content, showing that air under pressure has a remarkably beneficial effect in aiding the solution of the gold. Although this system of treatment has the disadvantage of requiring a larger number of presses to treat a given quantity of slime than the agitation method, still the cost of the agitation vats and other apparatus required for plants of the latter class counterbalances to some extent the first cost of the plants for the two systems. Moreover, this method has the advantage of return of water to the mill direct, no accumulation of liquors, and lower working costs.

Under the second subdivision, where the gold is brought into solution in agitation vats, presses are used as filtering medium only. The method is suitable for the treatment of slime from an ore which has been dry-crushed, or which contains but little water, and consequently requires a longer contact with cyanide solution in order to extract the gold. It cannot, however, be recommended for the treatment of slimes coming direct from a wet-crushing mill and carrying much water, as in this case the cyanide liquors accumulate to a large extent and have constantly to be run to waste, causing loss of cyanide, water, and to a certain extent, gold. This latter class of slime will be referred to under the head of double pressing.

As already stated this method is in vogue at the Brownhill, Ivanhoe and Great Boulder Co.'s mines. At the former, the dry-crushing material from the ball mills is divided into three grades by means of fans—coarse, medium, and fine. The first is ground and amalgamated in pans, the slime thus produced being agitated with cyanide and pressed. The second is leached in vats, and the third or slime portion is agitated in vats and pressed. By this means, very excellent results are obtained, and indeed no mine on the field obtains a closer extraction than the Brownhill, although the working costs are said to be high and the wear and tear great.

In the old plant Johnson's presses were used, but Dehne's presses have now been installed, and, indeed, the German presses are now almost universally used in Western Australia.

At the Ivanhoe much the same course is pursued, except that the ore is wet-crushed. The coarser sands are saved by means of a spitzluten and are amalgamated in pans. The medium sands are treated by cyanide in vats, and the fine slimes agitated and pressed. This method gives good results and the only exception which can be taken to it is in the treatment of the slime, which should be double-pressed instead of single. The slime as it comes from the mill, after being settled to a certain extent in tanks, is about half water, while that leaving the presses contains only 30%; as a result the liquors naturally accumu-

late to the extent of about 70% and have to be run to waste, causing a loss as already described.

At the Great Boulder slimes plant the material dealt with has been lying exposed to the air and the weather for some years and has consequently lost much of its moisture, so that here they have no difficulty in agitating and pressing the slime in the ordinary way.

Double Pressing.—This method, as already indicated, is the one employed for the treatment of slime which has been wet-crushed and consequently requires a long contact with cyanide in order to dissolve the gold. Although slightly more costly as regards working expenses than single pressing, it is to be recommended as the one most generally suitable to all classes of ore, as well as the one most likely to give the highest extraction. With regard to the treatment of sulphide slime at Kalgoorlie, there is little doubt but that the double pressing method will be the one eventually adopted.

The method of procedure is as follows: The finely pulverized slime is forced by means of compressed air or by pumps alternately into one of two presses set above two large agitation vats (which serve to a great extent also as sumps) where the water is separated from the slime and returned to the mill or the pans as the case may be. The press being now full of slime containing about 30% moisture is now opened and the slime discharged into the vat below, where it is quickly disintegrated by means of agitation arms kept in continuous slow motion, and becomes thoroughly mixed with the cyanide solution in the vat, causing the gold to be dissolved. From these vats the pulp, which now consists of slime and solution in about equal parts, flows into one of two montejus tanks, from which it is forced into a second series of four presses, where the cyanide solution is separated from the slime. The charge is washed and dried in the press and discharged into trucks and dumped, while the auriferous cyanide liquor and washes are conveyed through the zinc precipitation boxes back to the agitation vats, or to a small sump which is attached to the plant for washing purposes.

It will be noticed that the extra working cost of double pressing over single pressing is in connection with the filling and discharging of the two first presses for the separation of the water. It is estimated, however, that this cost will not exceed 25c. per ton at the outside, so that, taking into consideration the conservation of water, less loss of cyanide, and the probable saving of at any rate a few grains more of gold per ton, this cost is soon defrayed.

The great beauty of the filter press process lies in its capacity for handling large bodies of slime in a neat and clean manner and in the absolute control which can be exercised over the substance under treatment.

The chief objection to the process is its high working cost, and, on this account, it seems doubtful whether it will ever vie with decantation for the treatment of low-grade slime. No doubt, however, in a country where labor is cheap and water plentiful the cost of filter pressing could be considerably reduced.

THE MINING STOCK EXCHANGES IN 1900.

As shown in the accompanying stock market reviews this has been a prosperous year, indicating that public interest in mining investments is on the increase. The Colorado Springs Mining Stock Exchange has been the most active of all, due largely to the excellence of its management and the care taken to protect investors. The Boston Stock Exchange, where the leading copper stocks are dealt in, suffered in the early months of the year from the after effects of the Globe Bank failure, while in the last half a certain coterie of speculators controlled the market and practically checked business. In San Francisco the old Mining Exchange was barely kept alive by the dealings in the Comstock shares. The active interest manifested on the new Oil Exchanges, however, promises to revive the speculative prosperity of San Francisco. A fairly large business was also done in Salt Lake City and on the New York Exchanges.

The Boston Mining Stock Market in 1900.

The year opened in depression, as the boom of 1899 had left many investors loaded down with stocks approaching more or less nearly to entire worthlessness. The recovery of the market was therefore slow and irregular. In the Lake coppers the notable features were the advance in Tamarack, which closed at $335, or nearly double its lowest price; the depression of Osceola, and the steady gain of a group of the newer stocks—Baltic, Mohawk and Wolverine—which have able managements and seem likely to develop into steady dividend payers.

The Montana mines suffered from incessant litigation. Several companies paid good dividends, however, but trading in their shares was limited. Butte & Boston made its first dividend payment this year.

The outside or miscellaneous copper stocks were in fair demand, lead by Utah Consolidated and British Columbia.

The gold stocks were comparatively neglected during the early portion of the year. Later, however, Centennial-Eureka, of Utah, became quite a favorite, and was dealt in at rather high prices. Cochiti experienced a little boom at the close, but North American Gold Dredging, which was so prominent during the boom of 1899, has practically disappeared from sight, and Merced is very little dealt in.

FLUCTUATIONS OF MINING STOCKS AT BOSTON DURING 1900.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Copper:													
Adventure Con. (b)	$25	6·75	5·00	5·50	4·75	5·00	4·00	6·00	3·00	5·00	4·00	4·00	2·50
Allouez (b)	25	3·50	3·00	3·50	2·50	2·75	1·00	3·00	1·75	2·00	1·40	1·50	1·00
Amalgamated (a)	100					97·13	90·25	97·50	90·50	90·50	86·50	90·50	84·00
Anaconda (a)	25	41·25	39·50	46·00	42·00	52·00	44·00	53·88	45·00	45·00	41·75	40·50	39·50
Arcadian (b)	25	25·00	13·50	21·88	15·25	25·00	15·00	29·50	17·00	23·75	21·75	23·75	16·00
Arnold (b)	25	7·00	5·75	6·50	5·00	6·00	5·00	9·25	6·00	6·50	5·50	5·63	5·00
Ash Bed (b)	25	·50	·25			·50		1·00	·50				
Atlantic (b)	25	27·00	24·50	25·00	23·00	26·00	22·00	30·00	23·75	26·00	21·75	23·25	21·50
Baltic (b)	25	19·00	17·00	23·00	17·00	23·25	18·75	25·00	20·00	20·75	18·00	19·50	17·63
Bingham (h)	10	11·75	9·50	11·75	10·00	18·75	10·38	14·00	10·50	10·50	9·00	10·25	8·75
Boston & Mont. (a)	25	287·00	251·00	284·00	265·00	325·00	265·00	330·00	296·00	306·00	276·00	306·00	284·00
British Columbia, Ltd. (i)	5	11·00	8·63	11·00	9·50	10·75	9·00	13·13	10·75	12·25	10·00	10·88	10·13
Butte & Boston (a)	10	54·00	45·00	72·00	50·00	83·50	58·00	85·00	60.00	72·00	60·00	71·00	61·00
Calumet & Hecla (b)	25	755·00	735·00	772·00	740·00	765·00	725·00	760·00	745·00	758·00	695·00	725·00	700·00
Centennial (b)	25	20·50	15·13	20·50	15·65	24·75	16·50	25·25	19·00	18·63	13·00	18·50	15·00
Copper Range (b)	25	28·50	23·00	27·00	23·00	24·00	22·00	28·13	20·50	20·00	19·00	17·00	14·00
Elm River	12	6·75	4·25	5·50	4·50	5·75	3·75	6·50	4·50	4·75	3·13	4·75	3·00
Franklin (b)	25	16·00	14·00	15·75	14·13	16·75	14.00	18·00	15·00	15·50	12·75	14·00	12·00
Humboldt (b)	25	1·00		1·00				1·25	·75			·75	·50
Isle Royale (b)	25	27·00	21·00	28·50	21·50	32·50	25·00	34·50	25·50	26·50	23·00	26·00	22·25
Mass Con. (b)	25	9·00	8·00	7·50	5·88	7·00	5·00	9·25	7·00	7·50	6·25	7·00	6·25
Mayflower (b)	25	3·00	2·50	3·00	2·50	3·50	2·00	4·50	3·00	3·00	2·25	2·75	2·00
Michigan (b)	25	9·00	5·88	8·00	6·00	6·00	4·50	7·50	5·00	5·50	4·25	4·75	4·00
Mohawk (b)	25	17·00	11·50	15·00	12·25	17·00	12·63	20·50	15·50	16·00	13·50	16·00	11·75
Old Colony (b)	25	5·00	4·00	4·50	3·50	4·75	3·00	5·50	3·75	3·00	2·50	3·00	2·75
Old Dominion (c)	25	22·50	17·00	21·00	17·38	20·50	14·00	25·00	19·00	19·00	16·00	19·00	16·13
Osceola (b)	25	75·00	67·50	78·00	69·75	75·00	62·50	75·00	66·75	68·50	61·50	62·75	58·50
Parrot (a)	10	44·50	39·25	46·75	41·50	52·00	42·00	53·25	44·00	45·00	39·13	43·25	38·13
Quincy (b)	25	151·00	133·00	145·00	135·00	140·00	130·00	140·00	135·00	138·00	135·00	137·00	134·00
Rhode Island (b)	25	5·00	4·50	5·00	4·00	5·00	4·00	6·00	4·25	5·00	4·00	4·00	3·00
Santa Fé (j)	10	6·88	5·25	7·00	1·50	7·00	5·13	7·25	5·50	5·50	4·50	5·00	4·00
Tamarack (b)	25	190·00	169·00	193·00	180·00	195·00	179·50	199·00	190·00	195·00	172·00	194·00	180·00
Tecumseh (b)	25	4·50	3·00	4·00	3·50	3·50	3·25	5·00	3·75	3·25	2·75	3·50	2·00
Tri-Mountain (b)	25	8·00	6·75	7·88	7·00	9·00	6·50	10·50	8·00	8·75	7·00	7·25	6·50
Union (b)	25	3·50	3·00	2·50	2·25	3·00	2·25	3·50	3·00	2·00		2·00	
Utah Con. (h)	5	30·00	19·00	33·00	25·75	36·50	26·75	37·50	29·50	30·00	24·63	28·00	22·50
Victoria (b)	25	4·00	3·50	4·00	3·00	3·50	2·00	4·00	3·00	3·00	2·00	2·50	2·00
Washington (b)	25	1·63	1·13	1·25	1·00	1·25	1·00	1·25	1·00	1·00		·75	
White Knob (j)	100	16·00	12·00	34·00	15·00	32·00	29·00	30·00	18·00	20·00	15·00	18·00	10·00
Winona (b)	25	5·00	3·50	4·00	3·00	4·50	2·63	6·00	3·50	4·00	2·25	3·00	2·50
Wolverine (b)	25	42·00	35·00	43·00	40·00	49·00	39·25	43·00	40·00	41·00	37·50	39·88	35·50
Wyandotte (b)	25	3·00	1·63	2·00	1·75	1·75	1·00	2·50	1·50	2·50	1·00	1·25	1·00
Gold:													
Boston & C. C. (d)	2	·35	·20	·20	·15	·15	·13	·13		·13	·12	·13	
Centennial-Eureka (h)	25			24·00	23·00	29·25	22·25	28·50	23·00	25·00	22·50	24·00	22·75
Cochiti (j)	10	14·00	12·00	13·00	9·25	14·00	10·50	14·00	10·88	14·00	9·25	10·50	7·25
Gold Coin (Gilpin). (g)	5					·15	·10	·10				·10	
Melones (e)	10	1·75	1·50	1·25	1·00	3·00	1·13	3·25	2·00	2·50	2·00		
Merced (e)	15	8·50	6·00	7·50	5·50	6·50	6·00	6·50	5·50	6·50	4·50	5·50	
N. Amer. Dredging (a)	10	2·50	1·50	2·50	2·00	3·00	2·38	4·00	3·00	4·00	2·50	2·13	2·00
Pioneer (e)	10	2·50	2·00	2·00	1·13	1·50	1·00	·50	·40	·50	·40	·40	·25
Santa Ysabel (e)	5	9·00	7·00	6·50	1·50	2·00	1·00	1·25	·50	1·50	1·00	1·25	·75
United States (h)	25	7·88		9·50	7·38	9·00	8·50	12·50	8·50	9·25	7·25	9·25	8·00
Victor (d)	5	3·50	2·50	2·50				1·00	·75	1·00		1·00	
Zinc:													
Am. Z. L. & Sm. (g)	25	19·75	15·00	17·50	15·00	18·50	12·50	18·50	13·50	15·00	10·00	12·00	10·00
Continental (g)	10	4·00	3·25	4·00	3·50	4·00	2·75	4·25		2·75	2·00	2·50	1·75
Miscellaneous:													
Ætna (e)	5	4·50	4·20	4·00	3·50	4·00	3·00	3·00	2·50	2·50	2·00	2·00	1·50
Bonanza (d)	10	1·88	1·25	1·63	1·00	1·38	1·13	1·38	1·00	1·13	1·00	1·00	·65
Boston (e)	10	6·50	4·75	5·00	4·00	3·00		5·30		3·00	2·50	3·50	2·50
Breece (d)	25	2·50	1·50										
Catalpa (d)	10	·25		·25				·25	·20				
Crescent (d)	10	·20						·20					
Dominion Coal (f)	100	46·00	40·50	44·50	41·00	51·00	42·00	50·00	43·50	44·50	36·50	42·50	37·00
Dominion Coal, pref.	100	116·00	115·00	117·00	115·75	117·00	114·50	116·00	115·00	118·00	116·00	118·00	114·00
Dunkin (d)	10												
Mont. Coal & Coke (a)	25	9·00	7·38	8·00	7·00	9·50	6·50	9·50	7·25	8·25	7·00	8·25	6·63
Napa (e)	7							9·25					
New England Gas & Coke	100											16·00	13·50
New Idria (e)	5			10·25	10·00								
Total sales	...												

FLUCTUATIONS OF MINING STOCKS AT BOSTON DURING 1900.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Copper:													
Adventure Con. (*b*)	2·00		4·00	2·88	4·50	4·00	6·00	4·00	7·00	5·00	11.00	6·00	$17,011
Allouez (*b*)	1·13		1·50	1·13	1·50	1·25	2·50	1·50	3·25	2·50	2·75	2·25	19,614
Amalgamated (*a*)	88·25	84·50	90·00	86·50	89·00	85·00	98·63	85·25	100·50	90·25	96·50	89·88	143,080
Anaconda (*a*)	40·75		46·00	43·50	46·00	42·75	47·00	45·25	52·63	46·50	48·88	47·00	4,002
Arcadian (*b*)	23·00	18·00	22·25	19·00	20·50	16·00	20·50	17·00	27·00	17·00	23·50	20·75	85,503
Arnold (*b*)	5·25	4·00	4·00	3·50	4·50	3·50	4·88	4·00	6·75	4·00	5·50	4·75	12,621
Ash Bed (*b*)									·50		·25		7,071
Atlantic (*b*)	24·50	21·50	24·25	22·75	24·00	22·50	25·50	22·00	28·00	25·00	27·50	26·00	13,429
Baltic (*b*)	19·50	17·00	23·38	19·50	21·50	20·50	25·00	20·50	30·00	22·00	32·00	27·00	70,056
Bingham (*h*)	10·00	9·00	11·13	9·50	13·00	10·75	12·75	11·50	14·50	12·00	16·75	13·00	61,752
Boston & Montana (*a*)	310·00	289·00	322·50	297·00	322·00	300·00	341·00	312·00	339·00	315·00	335·00	319·00	82,756
British Columbia, Ltd. (*i*)	11·50	10·00	12·00	11·25	11·75	10·63	16·00	11·50	20·75	16·00	21·75	19·50	45,263
Butte & Boston (*a*)	66·00	62·00	56·00	60·00	63·00	52·00	69·00	54·00	97·00	61·00	95·00	77·50	94,548
Calumet & Hecla (*b*)	745·00	720·00	760·00	740·00	755·00	735·00	790·00	745·00	835·00	790·00	840·00	800·00	3,934
Centennial (*b*)	18·00	15·50	19·00	16·50	17·25	13·50	19·00	14·00	21·50	16·75	23·00	15·25	138,269
Copper Range (*b*)	16·75	13·00	20·75	15·50	19·50	18·00	22·50	17·50	26·75	20·00	33·50	25·00	38,925
Elm River	4·00	3·50	4·25	3·50	3·75	3·00	4·25	3·25	4·50	4·00	6·00	3·75	62,358
Franklin (*b*)	14·00	12·00	14·25	13·50	15·00	13·00	15·75	13·50	17·00	14·50	16·50	15·00	27,904
Humboldt (*b*)	·75				·40				·75	·40			2,600
Isle Royale (*b*)	28·00	24·00	29·75	26·50	31·63	28·00	37·25	28·50	41·00	34·75	39·50	30·00	113,186
Mass Con. (*b*)	7·00	6·00	6·75	6·00	7·00	6·25	10·50	8·63	14·75	9·00	14·50	12·00	45,328
Mayflower (*b*)	2·50	1·00	2·25	2·00	1·50	1·00	2·50	1·50	3·00	2·00	2·50	1·50	24,385
Michigan (*b*)	4·00	3·00	3·50	3·00	3·25	3·00	3·50	3·00	6·50	3·13	5·50	4·13	22,006
Mohawk (*b*)	17·75	11·75	18·00	16·00	17·75	16·00	21·00	16·00	24·00	19·25	24·00	22·00	46,883
Old Colony (*b*)	3·00	2·50	4·00	3·00	3·00	2·50	3·63	2·50	4·00	3·00	4·50	3·00	16,068
Old Dominion (*c*)	19·25	18·00	19·25	17·50	19·00	16·00	23·00	17·00	32·00	21·00	31·50	27·50	285,750
Osceola (*b*)	69·25	60·00	69·50	65·13	69·88	63·00	74·50	65·00	79·00	71·75	75·50	72·00	63,779
Parrot (*a*)	42·50	39·25	43·00	40·25	42·75	39·00	48·00	41·75	52·50	44·50	50·50	47·00	158,121
Quincy (*b*)	142·00	132·00	142·00	133·00	149·00	140·00	158·00	142·00	165·00	155·00	178·00	169·00	5,366
Rhode Island (*b*)	3·50	3·00	3·00	2·00	2·50	2·25	4·00	2·50	5·00	3·50	4·50	3·50	13,971
Santa Fé (*j*)	5·25	4·38	5·00	4·50	5·00	4·25	7·50	4·50	8·50	6·75	7·50	6·00	44,685
Tamarack (*b*)	197·00	175·00	216·00	196·06	239·00	218·00	260·00	229·00	294·00	255·00	343·00	271·00	12,598
Tecumseh (*b*)	2·50		2·50	2·00	1·50		2·00	1·25	2·65	1·75	2·00	1·63	6,159
Tri-Mountain (*b*)	7·75	6·75	9·00	7·25	9·75	8·00	12·00	8·75	13·00	11·00	20·75	12·50	69,641
Union (*b*)	1·00						2·00	1·50	3·50	2·00	3·75	3·00	9,133
Utah Con. (*h*)	29·50	25·25	32·63	27·75	31·88	28·00	34·50	29·13	36·00	31·25	35·00	33·25	148,384
Victoria (*b*)	2·00	1·50	2·25	2·00	2·25	2·00	3·50	1·88	3·88	3·00	3·75	2·25	20,126
Washington (*b*)							·65	·50	1·00		·60	·50	6,750
White Knob (*j*)	15·00	12·00	13·50	13·00	12·00	10·00	15·50	10·00	12·00	7·50			15,951
Winona (*b*)	3·00	2·50	3·50	2·75	3·43	3·00	3·50	2·75	4·50	3·38	4·50	3·25	29,057
Wolverine (*b*)	39·50	36·00	41·88	39·00	43·00	39·00	43·00	39·50	47·00	42·00	46·50	45·50	30,440
Wyandotte (*b*)	1·50	1·00	1·75	1·00	1·50	1·13	1·50	1·00	1·75	1·25	1·50	1·00	22,237
Gold:													
Boston & C. C. (*d*)	·04						·10						16,450
Centennial-Eureka (*h*)	25·00	22·00	23·75	22·50	24·00	18·00	20·50	19·50	27·00	20·75	25·50	23·00	38,223
Cochiti (*j*)	9·38	8·00	8·50	7·75	9·00	7·75	8·75	7·75	10·75	8·00	13·00	9·00	127,987
Gold Coin (Gilpin) (*g*)													4,195
Melones (*e*)	2·00								2·50	1·25			13,974
Merced (*e*)	5·50	5·00	6·00	5·00	6·00		6·00	5·00	6·50	5·00	5·50	5·00	5,256
N. Amer. Dredging (*a*)	2·50	1·50			11·00	10·50	1·00	·50	2·50	·75	1·00		13,555
Pioneer (*e*)	·25		·25	·15			·20	·10					6,879
Santa Ysabel (*e*)	·85								4·00	3·25	3·13	2·38	43,129
United States (*h*)	7·00		9·75	8·00	9·50	9·25	10·00	8·50	12·75	9·00	10·88	9·75	43,340
Victor (*d*)			1·00				·50		·90	·50			4,570
Zinc:													
Amer. Z. L. & Sm. (*g*)	10·00	9·00	10·00	9·00	9·13	8·00	9·00		13·75	10·00	13·00	12·00	21,242
Continental (*g*)	2·50	2·00			2·00				2·50	2·00	2·25	1·75	4,902
Miscellaneous:													
Ætna (*e*)	1·50	1·25	1·25		1·00		·75		1·00	·75	1·00	·75	9,625
Bonanza (*d*)	1·00	·75	·90	·75	·80	·75	1·25	·80	1·88	1·13	1·50	1·13	48,135
Boston (*e*)	3·00		3·00	2·50	2·50		3·50	3·00	3·00		4·75	3·50	6,060
Breece (*d*)					2·00		2·00	1·75			2·00		1,400
Catalpa (*d*)									·15				3,400
Crescent (*d*)	·10				·10								1,600
Dominion Coal (*f*)	43·00	37·50	41·50	38·50	43·00	37·50	42·00	38·25	45·00	38·50	40·75	36·00	114,314
Dominion Coal, pref.	111·00	110·00	114·00	110·00	111·00	111·00	114·00	110·00	114·00	112·00	113·00	108·50	4,486
Dunkin (*d*)			·15				·15				·15		1,411
Mont. Coal & Coke (*a*)	7·00	6·25	7·50	6·13	7·00	6·25	7·50	6·13	8·50	6·00	7·50	6·00	21,110
Napa (*e*)									4·00				175
New England Gas & Coke	19·00	7·50	14·50	11·50	18·63	7·00	15·25	11·50	17·50	13·25	14·00	11·00	20,680
New Idria (*e*)													150
Total sales													2,716,968

(*a*) Montana; (*b*) Michigan; (*c*) Arizona; (*d*) Colorado; (*e*) California; (*f*) Nova Scotia; (*g*) Missouri; (*h*) Utah; (*i*) British Columbia; (*j*) New Mexico.

FLUCTUATIONS OF MINING STOCKS AT COLORADO SPRINGS, COLO., DURING 1900.

Name of Company.	Par Value	January.		February.		March.		April.		May.		June.	
		B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.
Acacia	$1·00	·35	·45	·35	·39	·30	·38	·25	·34	·31	·39	·33	·36
Alamo	1·00	·15	·20	·16	·18	·15	·17	·14	·16	·14	·16	·13	·16
American Con	1·00	·06		·05	·07	·06		·06		·06		·06	
Anaconda	5·00	·38	·47	·36	·52	·35	·41	·35	·39	·24	·37	·34	·40
Anchor	1·00	·03		·03	·04	·03	·04	·03	·04	·04		·03	·04
Antelope	1·00	·03	·04	·03	·04	·03	·04	·03		·03	·04	·03	
Aola	1·00	·05	·06	·05		·05	·06	·05	·06	·06	·07	·05	·06
Argentum-Juniata	2·00	·15	·22	·18	·21	·19	·20	·20	·22	·19	·21	·20	
Banner	1·00	·05		·05		·04	·05	·04	·05	·05		·04	
Battle Mt. Con	1·00	·33	·36	·34	·37	·32	·36	·28	·31	·29	·32	.29	·31
Ben Hur	1·00	·07	·08	·07	·09	·07	·08	·06	·08	·07		·07	
Black Bell	1·00	·14	·16	·13	·15	·12	·15	·11	·13	·11	·12	·11	·12
Blue Bell	1·00	·12	·13	·12	·15	·10	·16	·13		·13		·12	
Buckhorn	1·00	·07	·08	·07		·07		·06	·07	·07		·06	·07
Cadillac Con	1·00	·02	·03	·02		·02		·02		·02	·03	·02	
Central Con	1·00	·06	·07	·06	·07	·07	·09	·06	·07	·06	·07	·06	·07
Champion	1·00	·08	·09	·08	·09	·07	·08	·08		·06	·07	·06	·07
Chicolo	1·00	·04	·05	·04		·04		·03		·03	·04	·03	
C. K. & N	1·00	·02	·03	·02	·03	·02	·03	·02		·02	·03	·03	
C. C. Columbia	1·00	·10	·13	·10	·12	·10	·11	·07	·08	·08		·07	·10
C. C. G. Ext	1·00	·11	·14	·11	·12	·10	·11	·08	·10	·07	·09	·08	·11
C. C. & Man	1·00	·13	·19	·13	·16	·10	·14	·11	·12	·11	·12	·10	·11
Copper Mt	1·00	·06	·13	·06	·08	·06	·07	·04	·06	·05	·06	·04	·05
Cripple Creek Con	1·00	·16		·16	·22	·14	·23	·14		·14	·15	·14	
Dante	1·00	·17	·20	·16	·17	·15	·18	·14	·16	·14	·15	·13	
Eclipse	1·00	·09	·10	·08	·09	·09		·08	·09	·08		·08	·09
Elkton Con	1·00	1·17	1·21	1·16	1·22	1·15	1·22	1·12	1·30	1·30	1·51	1·26	1·50
El Paso	1·00	·32	·38	·33	·38	·38	·43	·39	·41	·39	·46	·40	·44
Enterprise	1·00	·24	·35	·23	·36	·20	·25	·20	·27	·22	·26	·21	·22
Findley	1·00	·14	·16	·13	·15	·14	·20	·15	·19	·14	·16	·14	·16
Garfield Con	1·00	·15	·18	·15	·19	·15	·20	·20		·16	·18		
Gold Hill	1·00	·03		·03		·03		·03	·04	·04		·03	·04
Gold Sovereign	1·00	·11	·16	·12	·14	·12	·15	·10	·11	·10	·12	·10	·12
Hayden Gold	1·00	·03	·04	·03		·02	·03	·02	·03	·02	·03	·02	
Ida May	1·00	·26	·30	·28	·30	·26	·29	·27		·27	·31	·27	·33
Ingham Con	·50	·15	·19	·17	·20	·19	·22	·22	·26	·23	·27	·19	·23
Isabella	1·00	1·28	1·42	1·27	1·38	1·04	1·32	1·12	1·29	1·21	1·29	1·20	1·29
Jack Pot	1·00	·58	·62	·60	·62	·59	·63	·57	·68	·63	·69	·57	·64
Josephine	1·00	·04	·05	·03	·04	·02	·03	·02		·03		·02	·03
Key West	1·00	·05		·05	·06	·05		·04	·05	·04		·03	·04
Lexington	1·00	·19	·28	·18	·24	·17	·21	·14	·20	·16	·19	·17	·19
Magnet Rock	1·00	·04	·05	·04	·05	·04		·04		·04		·04	
Margaret	1·00	·03	·04	·03	·04	·03	·04	·03		·03	·04	·03	
Margery	1·00	·04	·06	·05		·05	·06	·04	·06	·04	·06	·04	
Matoa	1·00	·25	·31	·25	·29	·25	·26	·25	·27	·27	·33	·32	·37
Midway	1·00	·06	·08	·07	·08	·07	·08	·07		·06	·07	·06	
M. J. T	1·00	·03	·05	·04	·05	·04		·04		·04	·05	·05	
Mobile	1·00	·04		·04		·03	·04	·02	.04	·03	·04	·03	·04
Mollie Dwyer	1·00	·03	·04	·03	·04	·03	·04	·04		·04		·04	·07
Monarch	1·00	·10	·12	·10	·15	·15	·17	·07	·09	·08	·09	·08	·09
Morning Star	1·00	·04		·04	·05	·04		·03	·04	·04		·03	·04
Mountain Beauty	1·00	·10	·12	·10	·11	·10	·13	·09	·10	·10	·12	·09	·10
National	1·00	·11	·13	·11	·13	·10	·12	·08	·09	·08	·09	·09	·17
Nellie V	1·00	·08	·12	·10	·12	·11	·12	·11	·13	·11	·12	·12	·13
New Haven	1·00	·06	·08	·08	·10	·08	·09	·09		·08	·09	·08	·09
Olive Branch	1·00	·09	·10	·09		·08	·09	·07		·07	·08	·06	·07
Oriole	1·00	·06		·06		·05	·06	·04	·05	·04	·05	·05	·06
Orphan	1·00	·20	·23	·22	·25	·22	·23	·21	·22	·20	·23	·18	·19
Pelican	1·00	·03	·04	·03	·04	·03	·04	·02	·04	·03		·03	
Pharmacist	1·00	·11	·15	·13	·17	·13	·16	·10	·14	·12	·14	·12	·14
Pilgrim Con	1·00	·09	·12	·11	·15	·13	·15	·12	·13	·13	·14	·13	·14
Pinnacle	1·00	·25	·31	·20	·26	·20	·22	·19	·20	·20	·23	·19	·21
Portland	1·00	2·25	2·40	2·35	2·40	2·37	2·47	2·35	2·80	2·62	3·51	3·00	3·26
Prince Albert	1·00	·06	·07	·06		·05	·06	·04	·06	·04	·05	·04	
Princess	1·00	·06	·07	·06		·05	·06	·05	·07	·07		·06	.08
Progress	1·00	·10		·10		·09		·07	·09	·07		·07	
Pythias	1·00	·07	·08	·07	·08	·07		·06	·07	·06	·07	·06	
Republic	1·00	·07	·08	·07	·08	·06	·07	·06	·07	·06	·07	·06	
Robert Burns	1·00	·05	·06	·06		·06		·05		·05	·06	·04	·05
Rose Maud	1·00	·10	·12⅝	·10½	·12⅝	·11½	·13½	·10½	·11½	·10	·10½	·08	·10
Rose Nicol	1·00	·10	·14	·13	·14	·13	·14	·13	14	·14		·13	·14
Sliver Gold	1·00	01	·02	·01	·02	·01	·02	·01	·02	·01	·02	·01	·02
Specimen	1·00	·11	·12	·11	·13	·09	·11	·10	·12	·13	14	·13	·14
Theresa	1·00	·08	·09	·07	·09	·08		·07		·07		·07	·10
Trachyte	1·00	·07	·08	·06	·09	·07		·07	·08	·07	·08	·06	·07
Uncle Sam	1·00	·06	·07	·05	·07	·06	·07	·05		·05		·04	·05
Union	1·00	·39	·45	·44	·50	·49	·50	·45	·50	·42	·48	·40	·42
Virginia Mt	1·00	·07	·08	·08	·10	·09	·12	·09	·10	·08	·09	·09	·10
Work	1·00	·29	·32	·31	·37	·30	·37	·30	·36	·32	·35	·30	·33
Total sales													

FLUCTUATIONS OF MINING STOCKS AT COLORADO SPRINGS, COLO., DURING 1900.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		Decemb'r.		Sales.
	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	
Acacia	·34	·40	·35	·46	·38	·46	·37	·41	·37	·44	·34	·40	$2,512,512
Alamo	·14	·17	·12	·15	·12	·13	·12	·13	·11	·13	·11	·12	688,967
American Con	·06	·10	·08	·09	·06	·09	·04	·07	·07	·09	·06	·08	512,600
Anaconda	·34	·51	·47	·50	·40	·52	·40	·50	·46	·56	·45	·52	1,100,349
Anchor	·03	·04	·03	·04	·03	·04	·02	·04	·02	·04	·03	·04	348,000
Antelope	·03		·03		·02	·03	·02	·03	·03	·04	·02	·03	513,500
Aola	·06		·06	·07	·05	·07	·05	·06	·05	·06	·05	·06	469,480
Argentum-Juniata	·19	·30	·26	·31	·25	·28	·26	·29	·26	·31	·26	·29	535,577
Banner	·04	·05	·04	·05	·03	·04	·03	·04	·03	·04	·03	·04	351,500
Battle Mt. Con	·28	·30	·28	·31	·20	·29	·23	·27	·20	·27	·16	·22	479,500
Ben Hur	·07	·08	·07	·09	·08	·09	·08	·09	·07	·08	·06	·09	448,275
Black Bell	·11	·15	·11	·13	·08	·12	·10	·13	·11	·14	·12	·16	323,500
Blue Bell	·10	·13	·11	·13	·11	·13	·12	·16	·14	·15	·14	·15	471,114
Buckhorn	·06	·09	·07	·08	·06	·08	·06	·07	·06	·07	·04	·06	481,834
Cadillac Con	·02	·03	·02	·03	·02	·03	·02	·03	·03		·02	·03	514,000
Central Con	·08	·17	·08	·17	·06	·08	·07	·10	·07	·09	·07	·08	1,615,000
Champion	·07	·12	·08	·12	·06	·09	·07	·08	·05	·09	·07	·08	479,500
Chicolo	·03	·04	·02	·03	·02	·03	·02	·03	·03		·02	·03	765,500
C. K. & N	·03		·03		·02	·03	·02	·03	·02	·03	·02	·03	681,677
C. C. Columbia	·08	·09	·08	·11	·10	·12	·11	·12	·11	·12	·11	·12	2,411,000
C. C. G. Ext	·10	·17	·15	·19	·16	·21	·17	·18	·13	·17	·14	·15	1,065,449
C. C. & Man	·10	·14	·12	·14	·10	·12	·10	·11	·11	·12	·10	·11	1,612,378
Copper Mt	·04	·05	·04	·05	·03	·04	·04	·05	·04	·05	·03	·04	1,724,500
Cripple Creek Con	·13	·15	·13	·14	·10	·15	·12	·14	·13	·15	·11	·14	1,657,650
Dante	·13	·14	·12	·13	·09	·12	·09	·11	·10	·12	·09	·10	1,483,376
Eclipse	·08	·11	·09	·10	·09	·11	·09	·10	·08	·11	·09	·10	1,171,892
Elkton Con	1·29	1·63	1·53	1·89	1·64	1·90	1·68	1·89	1·86	1·94	1·86	1·90	1,776,177
El Paso	·39	·45	·43	·46	·40	·46	·41	·44	·42	·45	·40	·44	835,242
Enterprise	·20	·23	·20	·23	·16	·21	·15	·20	·15	·20	·10	·18	400,935
Findley	·14	·15	·13	·14	·13	·16	·14	·16	·14	·16	·10	·14	1,752,800
Garfield Con	·08	·17	·06	·10	·07	·10	·07	·10	·07	·10	·07		493,889
Gold Hill	·03	·05	·04	·05	·03	·05	·03	·04	·03	·04	·03		1,845,500
Gold Sovereign	·10	·11	·09	·10	·07	·10	·07	·10	·09	·11	·08	·09	2,003,932
Hayden Gold	·02		·02		·02		·01	·02	·02	·03	·02	·04	526,856
Ida May	·31	·34	·28	·35	·25	·30	·25	·28	·23	·27	·21	·25	578,150
Ingham Con	·20	·22	·18	·20	·18	·19	·16	·22	·20	·22	·20	·24	2,728,284
Isabella	1·24	1·28	1·13	1·34	·85	1·10	·86	·93	·66	·88	·63	·69	2,503,884
Jack Pot	·45	·60	·50	·56	·43	·59	·47	·60	·57	·60	·58	·75	578,953
Josephine	·01	·03	·02	·03	·02	·03	·02		·02		·02		352,100
Key West	·03	·05	·04		·02	·04	·03	·04	·03	·04	·03		676,000
Lexington	·16	·19	·16	·18	·13	·17	·13	·15	·14	·16	·13	·15	2,422,000
Magnet Rock	·04	·05	·04	·05	·03	·04	·02	·04	·04	·05	·04	·05	624,418
Margaret	·03	·05	·03	·05	·02	·03	·02	·04	·02	·03	·02	·03	453,500
Margery	·03	·04	·03	·05	·02	·04	·03	·05	·03	·04	·02	·04	606,500
Matoa	·35	·39	·29	·38	·15	·30	·16	·19	·15	·19	·17	·19	499,350
Midway	·06	·07	·04	·07	·05	·06	·05	·06	·05	·06	·04	·06	683,700
M. J. T	·04	·05	·03	·05	·03	·04	·03	·04	·04	·05	·04	·05	1 224,000
Mobile	·03	·07	·03	·04	·03	·08	·03	·04	·03	·04	·03	·04	416,500
Mollie Dwyer	·06	·08	·06	·08	·05	·08	·05	·06	·05	·06	·05	·06	2,864,500
Monarch	·08	·10	·11	·12	·08	·17	·09	·10	·08	·10	·09	·11	896,100
Morning Star	·03	·05	·04	·05	·04	·05	·04	·05	·04	·05	·03	·05	742,000
Mountain Beauty	·09	·10	·09	·10	·07	·10	·08	·09	·08	·09	·08	·09	1,854,620
National	·11	·15	·10	·12	·08	·09	·08	·09	·08	·10	·08	·10	5,480,456
Nellie V	·12	·13	·11	·13	·08	·12	·07	·10	·08	·09	·08	·09	867,250
New Haven	·08	·10	·09	·10	·07	·09	·07	·09	·09	·10	·09		3,284,233
Olive Branch	·06	·07	·06	·07	·05	·06	·05	·06	·05	·07	·04	·05	600,500
Oriole	·05	·06	·05	·06	·04	·06	·04	·05	·04	·05	·04	·05	526,766
Orphan	·18	·21	·17	·22	·15	·21	·15	·17	·15	·18	·10	·18	561,000
Pelican	·02	·03	·03		·02	·03	·02	·03	·02	·03	·02	·03	461,874
Pharmacist	·12	·15	·13	·15	·12	·14	·12	·13	·10	·13	·09	·10	1,955,850
Pilgrim Con	·13	·14	·13	·14	·09	·13	·09	·12	·08	·10	·06	·08	564,500
Pinnacle	·18	·23	·19	·24	·15	·22	·16	·19	·17	·20	·16	·19	782,300
Portland	3·00	3·30	3·00	3·50	3·00	3·50	3.22	3·50	3·30	3·43	3·20	3·38	336,463
Prince Albert	·04	·05	·04	·05	·04	·05	·05	·06	·05	·07	·05	·07	1,582.969
Princess	·06	·07	·05	·07	·05	·06	·04	·06	·05	·06	·05	·06	398,914
Progress	·05	·07	·06	·08	·06	·07	·05	·06	·06	·07	·05	·06	704,000
Pythias	·06	·07	·06	·07	·05	·06	·04	·06	·05	·06	·04	·06	714,000
Republic	·06	·07	·06	·07	·06	·07	·06	·08	·06	·07	·07	·09	924,700
Robert Burns	·04	·08	·06	·07	·05	·06	·05	·06	·06	·08	·05	·06	2,008,877
Rose Maud					·07	·09	·07	·09	·08	·10	·07	·09	1,115,943
Rose Nicol	·12	·14	·12	·14	·09	·14	·10	·12	·11	·13	·10	·12	974,110
Silver Gold	·01	·02	·01	·03	·02	·03	·02	·03	·02	·03	·02	·03	697,500
Specimen													1,244,050
Theresa	·07	·09	·07	·08	·06	·08	·06	·07	·07	·08	·06	·08	357,000
Trachyte	·07	·08	·07	·08	·05	·07	·05	·08	·06	·07	·05	·06	322,491
Uncle Sam	·04	·05	·04	·05	·02	·05	·04	·05	·04	·05	·04	·05	469,700
Union	·39	·46	·35	·41									582,078
Virginia Mt	·09	·11	·10	·12	·09	·12	·09	·10	·08	·10	·07	·09	728,911
Work	·28	·31	·28	·30	·20	·29	·22	·28	·25	·28	·21	·25	1,157,132
Total sa es													86.246.471

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1900.

Name and Location of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Acacia, g., Colo.	$1			·36						·33			
Adams Con., g., Colo.	10	·20	·13	·15	·10	·20	·12	·17					
Alamo, g., Colo.	1	·18	·14	·19	·15	·18	·16	·17	·15	·16	·13	·16	·13
Alice, g., Mont.	25	·50	·33	·70	·38	·65	·50	·67	·45	·75	·45	·45	·40
Amalgamated, c., Mont.	100	85·50	82·50	95·25	83·63	98·00	90·00	90·78	90·25	90·00	86·50	90·50	84·00
Anaconda, c., Mont.	25	40·75	38·00	46·25	40·13	51·63	40·63	54·88	44·13	46·00	40·50	43·00	38·00
Anaconda, g., Colo.	5	·46	·35	·47	·35	·42	·33	·38	·33	·36	·22	·37	·32
Anchoria-Leland, g., Colo.	1	·80	·70										
Argentum-Jun., g.s.l., Colo.	2	·24	·15	·22	·17	·23	·17	·25	·19	·21	·19	·22	·18
Arizona Cop. Sm., Ariz.	10					11·00	10·00	11·00	10·50				
Belcher, s.g., Nev.	3	·12	·06	·18	·05							·25	·14
Best & Belcher, g.s., Nev.	3	·44	·18	·52	·15	·32	·30			·30		·31	·20
Breece, i.s., Colo.	25	1·65	1·35	1·60	1·00	1·75	1·30	1·40	1·25	1·90	1·50	1·78	1·75
British Columbia, c., B. C.	5	12·00	8·25	11·00	8·50	10·63	8·50	12·00	10·50	12·00	9·50	10·88	8·75
Brunswick, g., Cal.	1	·40	·25	·33	·24	·39	·22	·33	·21	·30	·25	·28	·23
Bullion, s., Nev.	1			·04									
Cable Con., g., Colo.	1												
Catalpa, s.i., Colo.	10	·20	·15	·20								·15	
Challenge, s., Nev.	3			·18	·17								
Chollar, s.g., Nev.	3	·22	·15	·27	·15	·30	·15	·25	·10	·18	·15	·25	·09
Chrysolite, s.l., Colo.	50							·08	·06	·08	·04	·04	
Comstock Tunnel, s.g., Nev.	100	·04	·02	·05	·02	·05	·03	·04	·03	·04	·03	·07	·03
Comstock Tunnel Bonds.	100	·03	·02	·02		·04	·03	·03		·03		·03	
Con. Cal. & Va., s.g., Nev.	2½	1·75	1·30	1·55	1·25	1·75	1·25	1·80	1·45	1·55	1·30	1·65	1·35
Creede & Crip. C'k, g., Colo.	1	·13	·10	·12	·08	·14	·12	·15	·13			·15	·13
Crescent, s.i., Colo.	10	·12						·16	·15	·15			
Cripple Creek Con., g., Colo.	1	·16	·15			·22	·14	·15	·14	·15	·14	·14	
Crown Point, g.s., Nev.	3	·11	·07	·10	·05			·21				·09	
Daly, g., Colo	20					1·55	1·35	1.50	1·30	1·35	1·15	1·10	1·00
Damon, g., Colo.	1	·28	·25										
Deadwood-Terra, g., S. Dak.	25	·75	·50	·60	·40	·75	·50	·75	·55	·65	·50	·55	·40
Dunkin, s., Colo.	1	·10	·08									·14	
Elkton Con., g., Colo.	1	1·21	1·15	1·20	1·10	1·20	1·10	1·25	1·20	1·40	1·35	1·45	1·25
Father de Smet, g., S. Dak.	100	·10	·08					·10	·07	·07		·08	·05
Findley, g., Colo.	1	·15	·13	·14	·12	·13	·12						
Garfield Con., g., Colo.	1	·18	·15	·17	·15	·19	·15	·20	·18	·18	·17		
Gold Dollar, g., Colo.	1												
Golden Age, g., Colo	1	·06	·05	·06	·05	·05	·04	04		·05	·04	·08	·03
Golden Fleece, g.s., Colo.	1	·29	·20	·27	·25	·40	·26	·35	·24	·32	·28	·30	·21
Gould & Curry, g.s., Nev.	3	·20	·15							·30	·20	·16	·10
Hale & Norcross, s.g., Nev.	3	·48	·30	·30	·24	·33	·27						
Homestake, g., S. Dak.	100	55·00	50·00	65·00	35·00	75·00	50·00	50·00		55·00	50·00	73·00	50·00
Horn Silver, s.l., Utah.	25	1·05	·95	1·30	1·05	1·40	1·15	1·25	1·15	1·35	1·25	1·35	1·20
Iron Silver, s.i., Colo.	20	·57	·50	·72	·53	·80	·65	·70	·65	·70	·24	·63	·50
Isabella, g., Colo.	1	1·39	1·20	1·35	1·20	1·30	1·10	1·30	1·05	1·50	1·20	1·27	1·20
Jack Pot, g., Colo.	1	·60	·57	·60	·23	·68	·58	·65	·59	·70	·66	·56	
Justice, s., Nev.	1			·08		·10						·09	
Kingston & Pembroke, i., Ont.	10	·70	·35	·60	·30	·65	·25	·50	·35	·40		·23	·20
Lacrosse, g., Colo.	10	·14	·12	·14		·21	·12	·15	·14	·15	·06	·14	·12
Leadville Con., g.s., Colo.	10	·09	·07	·08	·07	·08	·05			·07	·06	·08	·06
Little Chief, s.l., Colo.	1	·22	·16	·18	·10	·22	·17	·25	·18	·24	·17	·20	·16
Mexican, g.s., Nev.	3	·35	·25	·35	·17	·35	·17	·35	·22	·34	·20	·28	·15
Mollie Gibson, s., Colo.	5	·28	·19	·25	·22	·27	·21	·25	·24	·26	·21	·26	·21
Moulton, g., Mont.	25	·30	·20	·30	·25	·30	·25	·30		·40	·20	·30	·20
Mt. Rosa, g., Colo.	1	·65	·50	·80	·57	·90	·70	·70				·78	
Occidental Con., g.s., Nev.	3	·15	·14										
Ontario, s.l., Utah.	100	9·00	7·00	9·00	7·75	9·00	8·00	8·50	8·00	9·00	7·00	8·00	6·50
Ophir, g.s., Nev.	3	·75	·65	1·60	·63	·90	·50	·87	·54	·70	·42	·82	·53
Pharmacist, g., Colo.	1	·16	·12	·17	·12	·17	·13	·14	·13	·15	·12	·14	·13
Phœnix Con., g., Ariz.	1	·08	·07	·12	·07	·13	·09	·12	·10	·08		·08	·07
Pinnacle, g., Colo.	1												
Plymouth, g., Cal.	10	·08		·21		·21	·10	·16	·16	·17	·10	·10	
Portland, g., Colo.	1	2·37	2·30	2·30	2·10	2·40	2·30	2·65	2·30	3·40	2·65	3·20	2·90
Potosi, g.s., Nev.	3	·40	·12	·30	·15	·30	·15	·38	·14	·25	·13	·20	·15
Quicksilver, Cal.	100	1·75	1·50	2·00	1·34	2·50	1·50	2·00	1·50	2·50	1·50	1·79	1·50
Quicksilver, Cal., pref.	100	8·00	7·50	8·00	7·50	10·13	7·50	9·00	7·00	9·25	7·50	8·75	6·50
Savage, s., Nev.	2½	·15	·05	·14	·07	·15	·08	·14	·05	·18	·04	·18	·07
Sierra Nevada, s., Nev.	3	·55	·38	·50	·32	·66	·31	·58	·33	·43	·25	·35	·24
Small Hopes, s.l., Colo.	20	1·15	·90	1·30	·90	1·10	1·00	1·10	·90	1·00	·75	·75	·45
Specimen, g., Colo.	1	·10	·09					·09		·12			
Standard Con., g.s., Cal.	10	2·85	2·40	2·85	2·00	3·50	2·89	4·00	3·15	4·00	3·00	4·25	2·50
Syndicate, g., Cal.	1	·08		·10		·10		·12		·10	·09	·06	
Tennessee, c., Tenn.	25	15·00	13·00	17·00	13·00	15·50	12·00	17·50	13·50	16·00	12·00	15·00	11·00
Tornado, g., Colo.	1	·47	·46			·55	·50			·50		·52	
Union Copper, N. C.	10												
Union Con., s., Nev.	2½	·23	·22	·35	·20	·37	·15	·30	·14	·19	·15	·20	·15
Utah Con., s., Nev.	1	·07	·02	·08	·05	·15	·06	·15	·09				
Virginia Mountain, g., Colo.	1					·10	·09					·09	
Work, g., Colo.	1	·34	·20	·35	·18	·37	·30	·36	·25	·35	·34	·34	·29
Yellow Jacket, s., Nev.	3	·25	·18	·20	·10	·18	·12	·30	·12	·21	·10	·18	·10
Zenobia, g., Colo.	1	·25	·20									·07	
Total sales.	...												

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1900.—*Continued.*

Name and Location of Company.	July.		August.		Sept.		October.		November		December		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Acacia, g., Colo.					·41		·38						$3,000
Adams Con., Colo.					·25		·30						3,160
Alamo, g., Colo.	·17	·14	·14	·13	·14	·13	·13		·13	·12	·13		93,300
Alice, g., Mont.	·42	·39	·55		·53		·55				·40		8,873
Amalgamated, c., Mont.	88·13	84·50	89·50	86·00	88·75	84·25	94·25	85·25	99·50	90·50	96·25	89·75	581,782
Anaconda, c., Mont.	44·00	38·50	47·13	43·38	45·50	40·25	47·50	42·00	52·75	44·25	49·50	46·50	407,828
Anaconda, g., Colo.	·50	·35	·50		·50	·40	·48	·43	·53	·47	·48	·40	20,400
Anchoria-Leland, g., Colo.													
Argentum-Jun., g.s.l., Colo.	·28	·18	·28	·26	·27	·26	·29	·27	·30	·27	·28		41,600
Arizona Cop. Sm., Ariz.													280
Belcher, s.g., Nev.	·15	·10	·16		·16		·16		·15				3,600
Best & Belcher, g.s., Nev.	·30	·15	·25	·13	·35	·25	·44	·33	·27				6,650
Breece, i.s., Colo.	1·00		1·10										1,175
British Columbia, c., B. C.	12·00	9·00	12·00	10·88	11·63	10·25	15·88	10·88	20·50	16·00	21·25	19·00	48,600
Brunswick, g., Cal.	·25	·10	·23	·12	·30	·24	·20	·09	·12	·11	·18	·11	38,320
Bullion, s., Nev.					·05		·12	·06					1,800
Cable Con., g., Colo.							·05				·05		4,000
Catalpa, s.i., Colo.							·12						1,500
Challenge, s.. Nev.	·10	·09											500
Chollar, s.g., Nev.					·21		·33	·20	·20				9,000
Chrysolite, s.l. Colo	·15	·07					·06	·05	·07	·06			6,080
Comstock Tunnel, s. g., Nev.	·04		·04	·03	·04	·03	·05	·04	·04				89,109
Comstock Tunnel Bonds.	·03		·04	·03	·04	·03			·04		·04		13,900
Con. Cal. & Va., s.g., Nev.	·03				·05								22,470
Creede & Crip. C'k, g., Colo.	1·65	1·35	1·50	1·30	1·35	1·10	1·35	·95	1·50	·95	1·55	1·30	35,650
Crescent, s.i., Colo.	·14	·13	·14	·13	·14	·13	·13		·14	·13	·11		4,300
Cripple Creek Con., g., Colo.	·12	·09					·10		·18	·12	·12	·10	65,400
Crown Point, g.s., Nev.	·15	·14	·14	·11	·14	·11	·15	·12	·15	·14	·13		8,506
Daly, g., Colo.			·21	·11	·14		·20	·12					7,525
Damon, g., Colo.	1·25	1·00							1·15	1·10	1·15		2,700
Dead wood-Terra, g., S. Dak.					·22						·15		2,090
Dunkin, s., Colo.	·50	·40			·50		·55	·50	·60	·58			1,600
Elkton Con., g., Colo.			·16						·15		·15		11,550
Father de Smet, g., S. Dak.	1·45	1·38	1·71	1·60	1·73	1·65	1·85	1·47	1·90		1·90		1,850
Findley, g., Colo.			*·47	·42	*·45	·40							7,500
Garfield Con., g., Colo.	·15										·40		6,200
Gold Dollar, g., Colo.							·10		·08				33,700
Golden Age, g., Colo.							·15		·28	·18	·26	·23	95,160
Golden Fleece, g.s., Colo.	·04	·03	·04	·03	·03		·03		·03				12,000
Gould & Curry, g.s., Nev.	·36	·28	·33	·29	·25	·23	·25	·18	·22	·20	·23		7,400
Hale & Norcross, s. g., Nev.	·20	·10	·19	·14	·37	·33	·85	·45					5,800
Homestake, g., S. Dak.	·26	·20	·18	·15	·27	·20	·41	·31					595
Horn Silver, s.l., Utah.	50·00		75·00						78·50		80·00	75·00	12,240
Iron Silver, s.i., Colo.	1·17	1·15	1·28	1·20	1·28	1·20	1·20	1·08	1·30	1·15	1·30	1·12	16,700
Isabella, g., Colo.	·55	·52	·67	·56	·70	·56	1·25		·77	·70	·90	·69	40,450
Jack Pot, g., Colo.	1·47	1·24	1·36	1·17	1·15	·90			·85	·67	·70	·65	14,200
Justice, s., Nev.	·52		·54	·50	·50	·48	·58	·56	·60	·54	·75	·62	700
Kingston & Pembroke, i., Ont.													21,200
Lacrosse, g., Colo.	·20		·25	·20	·20		·20						3,050
Leadville Con., g.s., Colo.	·15	·14	·14	·12					·17				22,600
Little Chief, s.l., Colo.	·07	·05	·07	·06	·07	·06	·08	·07	·07	·06	·07	·06	16,400
Mexican, g.s., Nev.	·18	·16	·17	·16	·18	·16	·19	·17	·18	·12	·18	·16	16,225
Mollie Gibson, s., Colo.	·18	·12	·32		·38	·25	·60	·34	·37	·14	·24		48,550
Moulton, g., Mont.	·30	·24	·27	·26	·28	·23	·28	·23	·26	·20	·26	·24	2,975
Mt. Rosa, g., Colo.					·35		·30				·30		10,900
Occidental Con., g.s., Nev.			·70		·64	·50	·55	·54					500
Ontario, s.l., Utah			·10										5,593
Ophir, g.s., Nev.	8·00	5·50	7·25	6·50	6·50	5·50	6·00		7·00	6·00	7·00		24,100
Pharmacist, g., Colo.	·75	·60	·76	·46	·60	·50	1·12	·55	·90	·80	·80	·65	134,000
Phœnix Con., g., Ariz.	·15	·14	·17	·14	·14	·11	·13	·12	·13	·11	·11		32,400
Pinnacle, g., Colo.	·10	·06			·11	·09	·15	·12	·14	·10	·12	·10	6,900
Plymouth, g., Cal.					·18		·19	·18	·20	·18			4,300
Portland, g., Colo.	·11	·10	·10		·14	·10	·15						3,900
Potosi, g.s., Nev.	3·05	2·90	3·40	3·20	3·30		3·50	3·15			3·40	3·20	15,235
Quicksilver, Cal.	·18	·10	·25		·24	·22	·29	·18	·16	·15	·15		2,895
Quicksilver, Cal., pref.	1·75	1·50	1·50		1·50				1·25		1·35		8,825
Savage, s., Nev.	7·50	6·50					8·25	7·75	9·75	9·00			8,900
Sierra Nevada, s., Nev.	·22	·16	·14	·07	·18	·07	·39	·18	·18	·17			17,100
Small Hopes, s.l., Colo.	·30	·16	·40		·36	·30	·27		·38	·27	·30		3,990
Specimen, g., Colo.	·45	·40			·80	·76							2,800
Standard Con., g.s., Cal.													12,639
Syndicate, g., Cal.	4·30	3·00	4·25	4·20	4·35	4·00	5·76	4·00	3·75	3·15	3·50	3·20	13,100
Tennessee, c., Tenn.	·09		·11	·10	·09		·09	·08	·12	·10	·20	·10	9,080
Tornado, g., Colo.	15·50	11·00	16·00	13·00	16·00	12·00	16·50	12·00	20·00	14·50	19·00	16·00	5,000
Union Copper, N. C.													25,700
Union Con., s., Nev.	2·50	2·00	3·38	2·13	3·75	2·25	3·38	2·50	5·50	2.88	5·75	4·50	6,525
Utah Con., s., Nev.	·20	·15			·19	·18							11,100
Virginia Mountain, g., Colo.					·06								5,000
Work, g., Colo.													42,000
Yellow Jacket, s., Nev.	·37	·29	·30	·29					·27		·27	·23	12,000
Zenobia, g., Colo.	·22	·10	·35	·25	·24	·20	·28	·25	·20				6,400
							·14		·13		·30		
Total sales.													2,363,525

* Assessment of 25c. on. C., copper; g., gold; i., iron; l., lead; s., silver.

In the general list the most prominent stocks have been Dominion Coal and New England Gas and Coke. Both have made substantial progress, though from time to time their stocks have been subjected to raids by the local gas combination.

The Colorado Springs Mining Stock Market in 1900.

The growth and importance of the mining stock market of this city cannot be more forcibly illustrated than by a comparison of the volume and cash value of the Cripple Creek stock transactions at its opening, September, 1894, and for 1900. The figures for these dates are respectively, 1894 (four months), 3,161,999 shares, valued at $769,318, and 1900, 193,696,227 shares, valued at $30,240,719. The total transactions to date are 642,691,901 share, valued at $95,463,647.

This represents the business done on the principal exchange only, and as there have been two and sometimes four exchanges operating here during the period mentioned, the total amount of investments of this character, is probably 25% greater than the figures quoted. It is worthy of note that mining stocks to the value of nearly $100,000,000 were transferred in a city of but 25,000 population.

While the general range of prices has several times been higher than at present, there has been no time in the history of the stock movement when the market exhibited more vitality and stability than it does now. Dividends on the various shares are also increasing.

PRICES OF INDUSTRIAL AND COAL STOCKS AT NEW YORK AND PHILADELPHIA DURING 1900.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
American Alkali	$50	3·00	2·00	3·00	2·63	2·50	2·00	2·75	2·25	3·00	2·00	2·88	2·25
Am. Alkali, pref.	50	1·75	1·00	1·13	1·00	1·00	·50	·75	·50	·75	·50	·75	·38
American Cement	10												
Amer. Sm. & Ref.	100	39·75	35·50	47.38	38·25	42·75	38·50	42·00	36·00	41.38	36·63	38·88	34·50
Am. Sm. & Ref., pref.	100	90·00	86·00	92·00	89·25	92·50	90·00	91·00	78·00	89·63	87·50	90·75	85·00
Am. Steel & Wire	100	58·38	45·25	59·75	55·38	58·50	53·25	58·00	37·00	40·88	33·00	37·50	21·00
Am. Steel & Wire, pref.	100	92·75	89·00	95·00	91·50	92·50	90·00	91·00	71·00	80·00	73·00	77·75	69·00
Bethlehem Iron	50	59·00	58·00	58·50	58·00	58·00		51·00	57·25	58·50	57·00	57·75	57·00
Bethlehem Steel	50	19·00	17·63	21·00	16·25	18·50	16·50	18·25	.17·00	17·00	12·75	16·25	14·00
Cambria Iron	50	45·50	45·00	44·76	44·50	44·75	43·25	44·50	44·25	44·50	43·00	44·00	43·00
Cambria Steel	50	22·25	20·75	22·50	20·50	22·00	19·50	23·25	20·00	20·25	17·25	18·63	14·28
Colo. Fuel & Iron	100	46·50	40·50	48·50	42·50	51·25	42·50	52·00	40·00	41·50	35·50	37·50	29·50
Colo. H. C. & Iron	100	16·50	15·00	27·50	16·63	20·00	15·00	21·00	17·00	17·00	14·00	16·00	14·00
Federal Steel	100	55·50	42·75	57·75	52·25	57·00	47·88	58·00	40·00	42·25	33·00	37·50	29·50
Federal Steel, pref.	100	76·00	70·75	77·50	73·00	76·50	72·00	76·00	68·00	69·50	65·00	68·88	60·75
Flemington C. & C.	100	26·00	20·00	23·00	18·00	25·00	19·00	30·00	20·00	30·00	22·00	27·00	23·00
National Lead	100	27·50	25·00	28·25	23·00	25·00	23·00	40·00	21·00	25·00	18·50	21·00	18·50
National Lead, pref.	100	107·25	104·50	106·50	103·75	106·00	103·50	106·00	89·00	104·00	95·00	98·50	94·75
National Salt	100	49·00	46·00	49·00	43·75	51·00	48·00	50·00	41·00	47·00	39·00	42·00	35·00
National Salt, pref.	100	81·00	77·00	80·00	76·00	80·00	77·00	79·00	76·00	76·00	67·00	70·00	67·00
Republic I. & Steel	100	24·13	19·38	27·50	22·50	24·00	19·75	24·00	17·00	18·00	12·00	14·50	8·75
Republic I. & S. pref.	100	68·50	64·75	70·75	67·25	69·00	65·50	67·00	59·00	60·00	52·00	58·13	49·88
Sloss-Sheffield I. & Steel	100			32·00	28·00	32·00	27·00	30·00	23·00	26·00	16·00	23·00	19·50
Sloss-Sheffield, pref.	100			73·00	69·00	71·00	66·00	70·00	59·00	68·00	59·00	65·00	59·25
Standard Oil	100	520·00	487·00	542·00	518·00	541·00	518·00	548·00	530·00	566·00	530·00	555·00	512·00
Susq. Iron & Steel	5	4·63	4·00	4·50	3·75	4·38	3·38	4·50	3·63	3·88	2·50	3·00	2·25
Tenn. C. I. & R.R.	100	87·75	79·75	104·00	86·50	100·00	90·00	99·00	77·00	82·75	68·88	76·50	62·00
United Gas Imp.	50	160·60	147·50	154·00	150·00	156·00	120·00	121·25	113·50	116·38	107·00	117·50	111·00
Va. Coal & Coke	100												
Total sales	...												

The New York Mining Stock Market in 1900.

There were fewer new mining companies brought out in New York during 1900 than in the year previous. On the Exchanges and on curb the copper group was most active, owing to the high price of the metal. Amalgamated of Montana, which paid 8% in dividends during 1900 was sold on curb up to November, when it was added to the "unlisted" department of the New York Stock Exchange. The stock fluctuated considerably, often without apparent reason. The largest daily transactions were during December. The same influence felt in Amalgamated controlled Anaconda. This company paid 16% in dividends during 1900, and sales of its stock were large. British Columbia copper, which was dealt in on curb, showed strength owing to favorable reports of its property. Tennessee copper was little dealt in as it is closely held. Union copper, of North Carolina, saw wide fluctuations. Arlington copper, of Bergen County, N. J., a new company, made a few sales on curb at $6·625 for its $10 shares.

In the gold list, business was confined principally to the Colorado stocks. The Cripple Creek shares were in demand. Portland paid regular dividends, and sold occasionally higher than last year. Elkton was strengthened by its consolidation with the Raven and Tornado companies, and is paying regular dividends. Isabella showed the customary fluctuations. In the Leadville list, Breece, Iron Silver, Small Hopes, and Adams Consolidated were in demand, all paying dividends. Homestake of South Dakota, which pays a double dividend each month and is therefore closely held, showed small transactions at advancing prices.

PRICES OF INDUSTRIAL AND COAL STOCKS AT NEW YORK AND PHILADELPHIA DURING 1900.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
American Alkali	2·25	2·00	2·13	1·75	1·75	1·25	3·00	1·50	3·50	2·13	2·63	1·50	$268,350
American Alkali. pref	·38												15,040
American Cement	8·00	7·75	8·00	7·75	8·00	6·50	6·88		9·00	8·13	8·50	8·13	23,012
Amer. Sm. & Ref	38·00	35·00	37·88	35·75	37·50	35·13	43·25	36·25	54·50	40·13	57·00	51·00	912,006
Amer. Smelt. & Ref., pf	89·00	72·00	89·50	87·50	90·00	86·88	92·00	88·00	99·00	90·13	98·00	95·00	161,315
Am. Steel & Wire	36·00	31·00	37·25	32·00	37·13	29·00	36·75	30·50	52·13	34·50	46·00	40·50	3,127,543
Am. Steel & Wire, pref	75·00	71·00	76·25	73·00	76·25	70·00	76·63	71·88	90·13	75·00	88·00	83·00	460,168
Bethlehem Iron	57·00	56·75	57·00	65·75	57·38	56·25	57·00	56·38	59·50	56·75	59·00	58·50	8,594
Bethlehem Steel	16·00	14·50	15·00	14·00	14·50	12·50	16·00	13·00	20·38	10·00	18·00	17·50	57,152
Cambria Iron	44·00	42·75	45·38	44·75	45·63	44·50	45·00	44·00	47·00	44·00	45·38	45·00	7,982
Cambria Steel	17·38	15·50	16·88	16·00	16·75	13·50	16·75	13·63	19·88	15·25	21·00	19·88	350,545
Colorado Fuel & Iron	36·00	32·00	36·50	32·38	35·88	29·25	40·50	30·63	54·88	37·50	57·00	50·00	584,855
Colo. H. C. & Iron	15·00	14·00	16·00	15·00	15·00	13·00	18·00	16·00	19·00	16·00	17·00	14·00	72,230
Federal Steel	35·00	32·00	35·75	31·75	35·00	30·00	41·00	31·38	52·75	37·75	58·00	48·00	2,615,675
Federal Steel, pref	68·00	64·00	67·75	64·88	68·00	61·00	89·63	62·00	77·75	67·50	79·50	75·00	392,299
Flemington C. & C	27·00	23·00	26·00	22·00	30·00	20·00	30·00	20·00	30·00	18·00	22·00	18·00	3,400
National Lead	21·00	19·00	20·00	15·88	18·00	16·25	20·75	16·75	23·00	18·50	22·00	18·00	79,788
National Lead, pref	98·00	96·00	97·00	88·00	92·25	88·00	99·00	89·50	99·00	92·88	95·00	91·38	21,419
National Salt	45·00	35·00	43·00	37·00	41·00	35·00	41·00	32·00	45·00	40·00	45·00	37·00	18,901
National Salt, pref	70·00	62·00	68·00	62·00	69·00	63·00	71·00	70·00	92·00	70·00	74·00	70·00	5,446
Republic I. & S	13·00	10·00	13·50	9·00	13·00	10·00	15·13	11·00	19·13	13·00	17·00	15·00	181,027
Republic I. & S., pref	57·00	53·00	55·00	49·00	55·25	50·00	57·75	51·75	65·75	56·25	66·00	62·50	179,501
Sloss-Shef. I. & Steel	21·00	10·00	20·00	19·00	19.00	18·00	19·00	18·00	26·00	19·00	25·00	23·00	18,084
Sloss-Shef., pref	65·00	62·00	67·00	65·00	68·00	62·00	66·00	61·00	71·00	66·00	71·00	68·00	15,803
Standard Oil	545·00	530·00	540·00	530·00	542·00	530·00	608·00	549·00	705·00	600·00	824·00	775·00	5,830
Susq. Iron & Steel	2·50	2·38	2·50	2·25	2·50	1·75	2·50	2·00	3·00	2·38	2·88	2·13	75,117
Tenn. C. I. & R.R.	72·00	60·00	72·50	68·25	71·75	51·25	61·00	49·00	79·75	54·13	73·00	59·00	1,611,694
United Gas Imp	115·88	111·00	115·50	112·50	113·00	105·00	119·00	106·00	127·00	114·50	125·00	124·00	130,208
Va. Coal & Coke	7·00	3·00	6·00	5·00	6·00	2·00	9·00	3·00	9·00	5·00	9·00	3·00	910
Total sales													11,403,894

FLUCTUATIONS OF MINING STOCKS AT SAN FRANCISCO DURING 1900.

Name and Location of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Belcher, Nev.	$3·00	·12	·09	·27	·09	·33	·24	·32	·12	·23	·09	·22	·16
Best & Belcher, Nev.	3·00	·27	·21	·37	·22	·48	·34	·34	·19	·38	·16	·31	·25
Caledonia, Nev.	3·00	·55	·43	·50	·34	1·40	·60	1·65	·95	1·35	·80	1·15	·90
Challenge, Nev.	3·00	·24	·09	·20	·17	·29	·20	·24	·15	·16	·11	·20	·13
Chollar, Nev.	3·00	·29	·18	·23	·17	·30	·16	·24	·10	·22	·16	·26	·18
Confidence, Nev.	3·00	·75	·60	·75	·65	·88	·74	·95	·70	·80	·65	·77	·60
Con. California & Va., Nev.	2·50	1·65	1·35	1·45	1·05	1·80	1·40	1·75	1·50	1·60	1·40	1·60	1·45
Crown Point, Nev.	3·00	·14	·03	·11	·07	·21	·12	·22	·12	·12	·07	·10	·07
Gould & Curry, Nev.	3·00	·26	·21	·24	·13	·21	·13	·29	·16	·22	·07	·15	·12
Hale & Norcross, Nev.	3·00	·41	·30	·33	·30	·32	·24	·41	·20	·34	·22	·29	·24
Justice, Nev.	2·00	·05	·02	·08	·01	·10	·05	·07	·02	·08	·01	·09	·06
Mexican, Nev.	3·00	·39	·29	·33	·19	·33	·20	·38	·22	·32	·22	·29	·19
Occidental, Nev.	3·00	·20	·15	·14	·10	·17	·12	·16	·08	·13	·07	·13	·11
Ophir, Nev.	3·00	·76	·65	·73	·53	·91	·53	·88	·57	·66	·47	·78	·58
Potosi, Nev.	3·00	·38	·17	·29	·24	·33	·18	·31	·14	·25	·17	·25	16
Savage, Nev.	2·50	·25	·08	·13	·10	·16	·13	·15	·06	·16	·06	·19	·13
Sierra Nevada, Nev.	3·00	·51	·41	·53	·34	·64	·36	·55	·39	·38	·29	·36	·27
Standard Con., Cal.	10·00	3·00	2·40	2·85	2·40	3·05	2·75	4·00	3·05	4·50	2·80	4·70	3·50
Union Con., Nev.	2·50	·32	·25	·32	·21	·26	·18	·33	·12	·27	·19	·24	·20
Utah Con., Nev.	1·00	·06	·03	·10	·03	·12	·08	·12	·09	·10	·06	·14	·08
Yellow Jacket, Nev.	3·00	·25	·21	·20	·16	·20	·75	·35	·13	·22	·13	·16	·10

This company has also a controlling interest in the Father de Smet mine and mill, the Caledonia, and other properties in the Black Hills. Sales of both Father de Smet and Caledonia were made, and though the former had levied a 25c. assessment, holders of stock were not anxious to sell, anticipating a "deal" with the Homestake company.

Of the California shares Standard Consolidated advanced to $5·75 in October, the highest in many years, owing to the dividend disbursements. Brunswick Consolidated attracted attention, as it is now under Standard management. In order to put the Brunswick mine in better workable shape increased assessments were levied. Quicksilver shares were in moderate demand.

The introduction of cheap electric power on the Comstock Lode gave a little life to these shares, but further assessments soon dampened public interest and limited trading. Gould & Curry advanced on purchases by Virginia City, Nev., people who sought the control of the property.

Alice of Montana advanced on reports of copper finds.

In the Utah stocks Horn Silver and Ontario advanced on fair trading. Kingston & Pembroke, of Ontario, made few sales.

An interesting event was the sale on January 9 of the United Verde property at Jerome, Ariz., for $500,000 to a representative of a reorganization committee. The company was reorganized under West Virginia laws with a capital stock of $3,000,000 in $10 shares, and shareholders in the old company received share for share, and in addition $10 in cash or a bond for an equal amount.

The San Francisco Stock Market in 1900.

Trading in mining stocks was considerably less than in 1899, and, in fact, was the poorest on record. The continued assessments on the Comstock shares have taken the life out of the market, and unless something beneficial results from the cheap electric power operations on the Lode we cannot expect an improvement in

FLUCTUATIONS OF MINING STOCKS AT SAN FRANCISCO DURING 1900.—*Continued.*

Name and Location of Company.	July.		August.		September.		October		November.		December.	
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Belcher, Nev	·18	·13	·23	·11	·20	·09	·26	·12	·20	·11	·18	12
Best & Belcher, Nev	·28	·19	·22	·15	·31	·15	·45	·23	·26	·17	·29	·17
Caledonia, Nev	1·15	·71	·82	·38	·48	·40	·49	·34	·54	·32	·48	·35
Challenge, Nev	·19	·12	·31	·17	·27	·18	·30	·12	·23	·12	·24	·14
Chollar, Nev	·21	·14	·19	·13	·21	·14	·28	·16	·16	·07	·16	·07
Confidence, Nev	·80	·65	1·10	·60	·87	·30	·89	·60	·85	·55	·63	·50
Con. California & Virginia, Nev	1·50	1·45	1·55	1·20	1·30	1·10	1·40	1·00	1·40	·94	1·50	1·20
Crown Point, Nev	·16	·07	·18	·11	·13	·10	·17	·10	·13	·08	·13	·10
Gould & Curry, Nev	·25	·12	·23	·15	·37	·19	1·05	·29	1·25	·60	·56	·31
Hale & Norcross, Nev	·34	·20	·25	·15	·27	·20	·45	·25	·28	·18	·21	·17
Justice, Nev	·10	·06	·08	·02	·07	·02	·08	·02	·04	·02	·04	·01
Mexican, Nev	·22	·14	.28	·16	·34	·24	·51	·29	·33	·21	·33	·18
Occidental Con., Nev	·11	·06	·12	·06	·27	·06	·11	·07	·10	·04	·05	·03
Ophir, Nev	·73	·65	·72	·48	·56	·45	1·00	·52	·86	·73	·76	·59
Potosi, Nev	·20	·06	·24	·13	·21	·10	·24	·13	·20	·08	·15	·11
Savage, Nev	·22	·11	·14	·08	·18	·08	·36	·18	·20	·12	·17	·06
Sierra Nevada, Nev	·36	·24	·38	·25	·32	·22	·51	·24	·39	·20	·31	·20
Standard Con., Cal	4·50	4·00	4·45	3·90	4·15	3·90	4·00	3·25	3·40	3·00	3·20	3·00
Union Con., Nev	·23	·16	·24	·17	·20	·16	·31	·16	·17	·11	·26	·18
Utah Con., Nev	·13	·08	·00	·06	·05	·04	·18	·04	·08	·06	·06	·03
Yellow Jacket, Nev	·31	·12	·35	·19	·23	·18	·28	·16	·25	·17	·24	·16

speculation. The sales of mining stocks on the San Francisco Stock Exchange in 1900 totaled 1,704,180 shares, showing a heavy decrease as compared with previous years.

Mining stock trading is being replaced by the California oil stocks, which are growing in favor on the new oil Exchanges. These oil shares represent a number of regular dividend paying properties. Among the oil shares dealt in at the close of the year are Hanford at $125 for its $10 par value shares; Oil City Petroleum at $37 for its $100 shares; Kern River, $16·50 for its $5 shares; Kern, $4·05 for its $1 shares; Buckhorn, $4 for its $10 shares; Home, $4·05 for

FLUCTUATIONS OF STOCKS AT PARIS DURING 1900.

Name of Company.	Location.	Par Val.	Latest Dividend.	Jan.–March.		April–June.		July–Sept.		Oct.–Dec.	
				H.	L.	H.	L.	H.	L.	H.	L.
		Frcs	Frcs.	Frcs.	Frcs.	Frcs.	Frcs.	Frcs.	Frcs.	Frcs.	Frcs.
Acieries de Creusot	France	2,000	85·0	1,998·0	1,900·0	1,980·0	1,890·0	1,860·0	1,775·0	1,795·0	1,715·0
Acieries de Firminy	France	500	175·0	3,820·0	3,500·0	3,810·0	3,500·0	3,790·0	3,500·0	3,700·0	3,375·0
Acieries de Fives-Lille	France	500		590·0	505·0	564·0	525·0	510·0	495·0	530·0	475·0
Acieries de Huta-Bank	Russia	500		5,000·0	4,350·0	4,900·0	4,575·0	4,645·0	4,250·0	4,500·0	3,850·0
Acieries de la Marine	France	500	60·0	1,980·0	1,700·0	1,850·0	1,665·0	1,768·0	1,635·0	1,675·0	1,550·0
Anzin, coal	France	500	260·0	7,300·0	6,730·0	6,990·0	6,800·0	6,990·0	6,475·0	6,875·0	6,205·0
Boleo, copper	Lower Cal.	500	176·0	3,110·0	1,980·0	3,219·0	2,930·0	2,700·0	2,590·0	2,690·0	2,550·0
Briansk, coal, iron	Russia	500		1,332·5	1,215·0	1,310·0	942·0	845·0	820·0	765·0	725·0
Champ d'Or, gold	Africa S	25	3·7	40·5	32·5	41·5	35·5	41·0	37·0	39·5	32·0
Courrieres, coal	France	300	90·0	3,200·0	2,810·0	3,115·0	3,010·0	3,035·0	2,690·0	2,949·0	2,593·0
Dombrowa, coal	Russia	500	12·5	1,140·0	1,105·0	1,111·0	990·0	1,020·0	940·0	1,030·0	980·0
Donetz, steel	Russia	500		1,235·0	1,190·0	1,175·0	930·0	900·0	880·0	880·0	437·0
Dynamite Centrale	France	500	22·5	473·0	450·0	464·0	435·0	430·0	410·0	437·0	410·0
Escombrera-Bleyberg	Spain	500	70·0	1,370·0	1,255·0	1,315·0	1,272·0	1,260·0	1,170·0	1,229·5	1,158·0
Huanchaca, silver	Bolivia	125	5·0	142·0	57·7	176·0	147·5	146·0	135·0	155·5	144·0
Laurium, zinc, lead	Greece	500	30·0	620·0	585·0	609·0	585·0	580·0	550·0	509·0	408·0
Malfidano, zinc	Italy	500	50·0	1,400·0	1,350·0	1,350·0	1,210·0	1,223·0	1,138·0	1,173·0	1,045·0
Metaux Cie. Fran. de	France	500	10·0	539·0	502·0	510·0	475·0	570·0	465·0	560·0	484·0
Mokta-el-Hadid, iron	Algeria	500	35·0	1,220·0	1,220·0	1,225·0	1,195·0	1,190·0	1,125·0	1,152·0	962·0
Napthe Baku	Russia			847·5	709·0	842·0	815·0	820·0	777·0	782·0	733·7
Napthe, Le	Russia			1,300·0	1,300·0	1,300·0	1,300·0	1,300·0	1,300·0	1,300·0	1,300·0
Napthe Nobel	Russia			717·0	660·0	695·0	665·0	675·0	607·5	622·5	532·5
Napthe Nobel parts	Russia			14,525·0	13,100·0	14,025·0	13,362·0	13,650·0	12,150·0	12,450·0	11,090·0
Nickel	New Cal.	250	17·5	570·0	360·0	521·0	470·0	531·0	460·0	516·0	490·0
Penarroya, coal	Spain	500	100·0	2,949·0	2,300·0	2,820·0	2,750·0	2,780·0	2,500·0	2,800·0	2,595·0
Salines de l'Est, salt	France	500	5·0	280·0	215·0	280·0	210·0	250·0	210·0	220·0	210·0
Salines du Midi, salt	France	500	25·0	1,095·0	998·0	1,060·0	1,010·0	950·0	720·0	930·0	910·0
Vieille Montagne, zinc	Belgium	80	36·0	799·0	774·0	845·0	750·0	765·0	710·0	869·7	650·0

FLUCTUATIONS OF STOCKS IN LONDON DURING 1900.

Name of Company.	Location.	Authorized Capital.	Par Value.	Divid'nds per share in 1900.	January-March.	
					H.	L.
		£	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Alaska-Mexican, g.	Alaska	200,000	1 0 0	1 7½	1 2 6	15 0
Alaska-Treadwell, g.	Alaska	1,000,000	5 0 0	6 0	5 5 0	4 15 0
Anaconda, c.	Montana	6,000,000	5 0 0	16 4	10 3 9	8 0 0
De Lamar, g.s.	Idaho	400,000	1 0 0	6	5 0	1 3
El Oro, g.	Mexico	1,000,000	1 0 0	1 0		
Grand Central, g.s.	Mexico	300,000	1 0 0	2 0	1 7 6	1 0 0
Hall Sm. & Mg., c.s.	British Col.	250,000	1 0 0		6 9	1 0
Le Roi, g.	British Col.	1,000,000	5 0 0		5 12 6	4 10 0
Lillie, g.	Colorado	250,000	1 0 0	9	1 0 0	15 0
Montana, g. s.	Montana	660,000	1 0 0		5 0	3 6
Mountain Copper	California	1,250,000	5 0 0	1 0 0	6 17 6	5 12 6
Newfoundland, c.	Newfoundland.	250,000	1 0 0		12 6	5 0
Palmarejo & Mexican, g.	Mexico	700,000	1 0 0		3 0	6
Stratton's Independence, g.	Colorado	1,100,000	1 0 0	7 4	3 1 3	2 10 0
Copiapo, c.	Chile	200,000	2 0 0	7 4	4 7 6	3 5 0
Frontino & Bolivia, g.	Colombia	140,000	1 0 0		2 1 3	1 13 9
St. John del Rey, g.	Brazil	600,000	1 0 0	2 6	1 10 0	1 5 9
Utah Con., g.	Utah	300,000	1 0 0		7 12 6	5 10 0
Velvet, g.	British Col.	100,000	1 0 0		1 5 0	1 0 0
Ymir, g.	British Col.	200,000	1 0 0		1 16 3	1 2 6
British Am. Corp	British Col.	1,500,000	1 0 0	2 0	19 3	13 6
Linares, l.	Spain	45,000	3 0 0	1 9 0	10 0 0	8 5 0
Mason & Barry, c.sul.	Portugal	420,000	2 0 0	10 0	5 2 6	3 17 6
Rio Tinto, c.	Spain	1,625,000	5 0 0	4 5 0	57 10 0	47 10 0
Rio Tinto, pref.	Spain	1,625,000	5 0 0	5 0	6 10 0	5 15 0
Tharsis, c.	Spain	1,250,000	2 0 0	15 0	10 12 6	8 15 0
Assoc. Gold Mines	W. Australia	500,000	1 0 0	1 6	7 10 0	4 17 6
Broken Hill Prop., s.	N. S. Wales	384,000	8 0	4 6	2 9 0	2 1 3
Great Boulder Prop.	W. Australia	175,000	2 0	1 6	1 17 6	1 12 6
Hannan's Brownhill, g.	W. Australia	140,000	1 0 0	1 7 6	11 0 0	9 2 6
Ivanhoe Gold Corp.	W. Australia	1,000,000	5 0 0	1 5 0	15 5 0	12 12 6
Kalgurlie, g.	W. Australia	120,000	1 0 0		9 3 9	6 12 6
Lake View Consols, g.	W. Australia	250,000	1 0 0	1 5 0	14 7 6	11 5 0
Mt. Lyell M. & R., l. c.	Tasmania	900,000	3 0 0	17 0	10 7 6	8 7 6
Mt. Morgan, g.	Queensland	1,000,000	1 0 0	7 2	5 5 0	4 15 0
Waihi, g.	New Zealand	320,000	1 0 0	10 0	10 2 6	9 0 0
Champion Reef, g.	Colar Fields	220,000	10 0	13 0	6 3 9	5 3 9
Mysore Gold	Colar Fields	250,000	10 0	13 6	6 3 9	5 11 3
Nundydroog, g.	Colar Fields	242,000	1 0 0	6 0	3 8 9	2 16 3
Ooregum, g.	Colar Fields	145,000	1 0 0	6 0	3 17 6	3 5 0
Ooregum, pref., g.	Colar Fields	120,000	1 0 0	8 0	5 1 3	4 2 6
British S. Af. Chartered	South Africa	5,000,000	1 0 0		3 16 3	3 0 0
Cape Copper	South Africa	600,000	1 0 0	18 0	5 17 6	4 17 6
Cape Copper, pfd.	South Africa	150,000	2 0 0	18 0	5 15 0	4 10 0
City & Suburban, g.	Transvaal	1,360,000	4 0 0		5 5 0	4 5 0
Cons. Deep Level, g.	Transvaal	200,000	1 0 0		1 10 0	1 0 0
Crown Reef, g.	Transvaal	120,000	1 0 0		14 5 0	12 0 0
De Beers Cons., d.	Cape Colony	3,950,000	5 0 0		29 15 0	22 15 0
Ferreira, g.	Transvaal	90,000	1 0 0		20 10 0	18 10 0
Geldenhuis Deep, g.	Transvaal	350,000	1 0 0		9 5 0	7 2 6
Geldenhuis Est., g.	Transvaal	200,000	1 0 0		6 7 6	5 0 0
Henry Nourse, g.	Transvaal	125,000	1 0 0		7 10 0	6 10 0
Jagersfontein, d.	Orange Fr. St.	1,000,000	5 0 0	6 0	16 7 6	11 10 0
Johannesburg Con. Invest.	South Africa	2,750,000	1 0 0		1 16 3	1 8 9
Jubilee, g.	Transvaal	50,000	1 0 0		5 15 0	4 5 0
Langlaagte Est., g.	Transvaal	470,000	1 0 0		3 5 0	2 7 6
May Con., g.	Transvaal	290,000	1 0 0		5 0 0	3 12 6
Meyer & Charlton, g.	Transvaal	100,000	1 0 0		5 0 0	3 5 0
Namaqua, c.	Cape Colony	200,000	2 0 0	16 0	4 15 0	3 17 6
Primrose (new), g.	Transvaal	300,000	1 0 0		3 16 3	3 2 6
Rand Mines, g.	South Africa	490,000	1 0 0		37 6 3	31 7 6
Robinson, g.	Transvaal	2,750,000	5 0 0		9 0 0	7 5 0
Sheba, g.	Transvaal	1,100,000	1 0 0		1 18 9	1 7 6
Simmer & Jack Prop., g.	Transvaal	5,000,000	5 0 0		5 11 3	4 17 6
Wolhuter, g.	Transvaal	860,000	4 0 0		4 7 6	2 10 0

its $1 shares; Sterling, $2·90 for its $1 shares, and Twenty-eight, $2·50 for its $10 shares.

The Salt Lake Mining Stock Market in 1900.

But for a few investment stocks of unquestioned merit, trading has been uninteresting. A feature, however, has been the entrance into the dividend paying

FLUCTUATIONS OF STOCKS IN LONDON DURING 1900.—*Continued.*

Name of Company.	April–June.		July–September.		October–December.		Year.	
	H.	L.	H.	L.	H.	L.	H.	L.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s.d.
Alaska-Mexican, g.	1 0 0	12 6	1 1 3	16 3	1 1 3	16 3	1 2 6	12 6
Alaska-Treadwell, g	6 2 6	4 15 0	5 5 0	4 17 6	5 5 0	4 17 6	5 5 0	4 15 0
Anaconda, c.	10 17 6	8 2 6	9 6 3	8 2 6	10 5 0	8 17 6	10 17 6	8 0 0
De Lamar, g.s.	5 0	2 6	4 0	2 6	5 0	2 6	5 0	1 3
El Oro, g.			1 6 3	1 2 6	1 6 3	1 0 0	1 6 3	1 0 0
Grand Central, g.s.	1 1 3	12 6	15 0	10 0	13 9	1 0 0	1 7 6	10 0
Hall Sm. & Mg., c.s.	2 0	1 0	2 6	1 0	5 9	1 6	6 9	1 0
Le Roi, g.	6 12 6	5 15 0	7 16 3	6 7 6	8 10 0	7 0 0	8 10 0	4 10 0
Lillie, g	1 0 0	7 6	12 6	8 9	15 0	7 6	1 0 0	7 6
Montana, g.s.	5 0	3 0	4 0	3 0	4 0	2 9	5 0	2 9
Mountain Copper	5 15 0	5 5 0	6 10 0	5 5 0	5 15 0	4 15 0	6 17 6	4 15 0
Newfoundland, c.	10 0	2 6	7 6	2 6	7 6	1 3	12 6	1 3
Palmarejo & Mexican, g.	3 0	1 0	4 0	9	2 6	2 0	4 0	6
Stratton's Independence, g.	2 18 9	2 12 6	3 1 3	2 7 6	2 18 9	1 0 0	3 1 3	1 0 0
Copiapo, c.	4 10 0	4 0 0	4 5 0	3 10 0	4 2 6	3 7 6	4 10 0	3 5 0
Frontino & Bolivia, g.	1 18 9	1 11 3	1 16 3	1 8 9	2 0 0	12 6	2 1 3	12 6
St. John del Rey, g	1 11 3	1 7 6	1 6 3	1 5 0	1 7 6	1 3 9	1 11 3	1 3 9
Utah Con., g.	7 7 6	4 15 0	6 10 0	5 0 0	7 2 6	6 0 0	7 12 6	4 15 0
Velvet, g.	1 2 6	17 6	1 2 6	18 9	1 8 9	1 2 6	1 8 9	17 6
Ymir, g.	1 16 3	1 6 3	1 15 0	1 10 0	1 16 3	1 8 9	1 16 3	1 2 6
British Am. Corp.	16 0	13 0	17 3	14 0	17 6	15 6	19 3	13 0
Linares, l.	10 0 0	9 0 0	10 10 0	9 0 0	10 10 0	8 10 0	10 10 0	8 5 0
Mason & Barry, c.sul.	5 2 6	3 17 6	4 2 6	3 12 6	4 0 0	2 17 6	5 2 6	3 12 6
Rio Tinto, c.	59 10 0	51 17 6	58 12 6	52 7 6	59 2 6	56 5 0	59 10 0	47 10 0
Rio Tinto, Pref	6 5 0	6 0 0	6 10 0	6 2 6	6 7 6	6 0 0	6 10 0	5 15 0
Tharsis, c.	10 10 0	7 15 0	9 2 6	8 0 0	9 0 0	8 7 6	10 12 6	7 15 0
Assoc. Gold Mines	5 7 6	2 16 3	4 0 0	3 1 3	3 10 0	3 3 9	7 10 0	2 16 3
Broken Hill Prop., s.	2 9 0	2 5 0	2 9 0	2 7 6	2 12 6	2 8 9	2 12 6	2 1 3
Great Boulder Prop.	2 0 0	1 10 0	1 13 6	1 12 0	1 11 9	1 5 9	2 0 0	1 5 9
Hannan's Brownhill, g	10 15 0	7 10 0	8 10 0	6 3 9	5 8 9	4 11 3	11 0 0	4 11 3
Ivanhoe Gold Corp.	14 10 0	8 17 6	10 13 9	9 16 3	10 12 6	9 10 0	15 5 0	8 17 6
Kalgurlie, g.	8 0 0	5 0 0	6 2 6	5 12 6	5 16 3	4 6 3	9 3 9	4 6 3
Lake View Consols, g.	14 16 3	10 10 0	14 0 0	11 12 6	14 11 3	11 10 0	14 16 3	10 10 0
Mt. Lyell, M. & R., l.c.	10 5 0	7 17 6	7 17 6	7 5 0	7 12 6	6 0 0	10 7 6	6 0 0
Mt. Morgan, g.	5 5 0	4 16 3	5 3 9	4 18 9	5 5 0	5 0 0	5 5 0	4 15 0
Waihi, g.	10 7 6	9 15 0	10 8 9	9 13 9	12 2 6	10 15 0	12 2 6	9 0 0
Champion Reef, g.	6 7 6	5 18 9	6 1 3	5 6 3	6 2 6	5 18 9	6 7 6	5 3 9
Mysore Gold	6 11 3	6 1 3	6 5 0	5 15 0	6 2 6	5 11 3	6 11 3	5 11 3
Nundydroog, g.	3 11 3	3 6 3	3 7 6	3 5 0	3 8 9	3 2 6	3 11 3	2 16 3
Ooregum, g.	4 2 6	3 15 0	4 0 0	3 12 6	3 18 9	3 15 0	4 2 6	3 5 0
Ooregum, pref., g.	5 5 0	4 15 0	5 2 6	4 15 0	5 3 9	4 15 0	5 5 0	4 2 6
British S. Af. Chartered.	3 16 3	3 5 0	3 12 6	3 0 0	3 12 6	3 5 0	3 16 3	3 0 0
Cape Copper	6 12 6	5 11 3	6 3 9	5 12 6	6 5 0	5 2 6	6 12 6	4 17 6
Cape Copper, pfd.	6 5 0	5 5 0	5 17 6	5 0 0	6 3 9	5 2 6	6 5 0	4 10 0
City & Suburban, g.	6 2 6	4 10 0	5 17 6	5 5 0	5 15 0	5 2 6	6 2 6	4 5 0
Cons. Deep Level, g.	1 12 6	1 2 6	1 7 6	1 2 6	1 7 6	1 0 0	1 12 6	1 0 0
Crown Reef, g.	16 15 0	12 5 0	16 5 0	14 15 0	15 15 0	14 15 0	16 15 0	12 0 0
De Beers Cons., d.	28 17 6	27 7 6	28 10 0	26 17 6	29 7 6	28 8 9	29 15 0	22 15 0
Ferreira, g.	23 0 0	18 10 0	23 0 0	20 10 0	22 10 0	20 0 0	23 0 0	18 10 0
Geldenhuis Deep, g.	10 10 0	8 15 0	10 12 6	9 10 6	10 10 0	9 10 0	10 12 6	7 2 6
Geldenhuis Est., g.	7 7 6	5 10 0	7 2 6	6 2 6	7 0 0	6 5 0	7 7 6	5 10 0
Henry Nourse, g.	8 7 6	6 17 6	9 0 0	8 5 0	9 1 3	8 7 6	9 1 3	6 10 0
Jagersfontein, d.	16 10 0	15 10 0	16 15 0	16 0 0	17 6 0	16 10 0	17 6 0	11 10 0
Johannesburg Con. Invest.	2 3 9	1 8 9	2 5 0	1 18 9	2 3 9	1 18 9	2 5 0	1 8 9
Jubilee, g.	6 15 0	5 0 0	6 15 0	5 5 0	6 10 0	5 10 0	6 15 0	4 5 0
Langlaagte Est., g.	3 15 0	2 15 0	3 13 9	3 0 0	3 13 9	3 5 0	3 15 0	2 7 6
May Con., g.	4 18 9	3 15 0	4 15 0	4 5 0	4 11 3	4 0 0	5 0 0	3 12 6
Meyer & Charlton, g.	5 15 0	4 10 0	5 15 0	4 17 6	5 12 6	5 0 0	5 15 0	3 5 0
Namaqua, c.	5 15 0	4 10 0	5 1 3	4 10 0	5 10 0	4 15 0	5 15 0	3 17 6
Primrose (new), g.	4 3 9	3 10 0	4 5 0	3 15 0	4 1 3	3 15 0	4 5 0	3 2 6
Rand Mines, g.	42 0 0	36 0 0	42 5 0	38 16 3	40 15 0	39 7 6	42 5 0	31 7 6
Robinson, g.	9 10 0	7 17 6	9 12 6	8 7 6	9 7 6	8 15 0	9 12 6	7 5 0
Sheba, g.	1 7 6	18 9	1 3 9	1 0 0	1 2 6	16 3	1 18 9	16 3
Simmer & Jack Prop., g.	6 6 3	5 0 0	6 13 9	6 1 3	6 13 9	6 2 6	6 13 9	4 17 6
Wolhuter, g.	5 2 6	3 12 6	5 0 0	4 2 6	4 17 6	4 2 6	5 2 6	2 10 0

C., copper ; d., diamonds ; g., gold ; l., lead ; s. silver.

mines list of the Gemini, Silver Shield, Utah and Rocco-Homestake, the last being a Nevada property. Daly-West takes first place among the dividend favorites, advancing in price from $12 bid at the beginning of the year to over $26·50 near the close. Silver King, its neighbor, also gained notably, selling up to $75. Swansea made occasional sales, closing at $4, but it is very strongly held owing to uniform dividends. Ontario stopped its quarterly dividend after the judgment

obtained against it in the Crown Point suit. Ontario shares closed at $5·90. Centennial-Eureka has been disappointing, owing in part to the cutting of the quarterly dividend one-half; the stock closed the year at $24·25. Mammoth has been erratic, selling around $2, as the court had decided the suit with Grand Central in the latter's favor. Horn Silver, around $1·10, has done little. Consolidated Mercur shares were quoted around $3·35 in December, while during the year they hardly kept pace with affairs at the mines. Grand Central fluctuated considerably in consequence of its trespass suit against the Mammoth, and sold in December up to $5·50.

Among the speculatives, Star Consolidated supplied the biggest sensation as it had uncovered some rich ore, closing the year at 76c. Lower Mammoth has had many fluctuations and several assessments, but closes the year strong and in demand around $1·65. Daly and Ajax strengthened near the close; the former selling around $2 and the latter at 62c. May Day in its contest with the Yankee Consolidated furnished life to the market on several occasions, closing the year at 42c.; the latter closed at 11c.

The metal mines of the United States paid $51,502,000 in dividends during 1900, of which the copper mines contributed $33,433,000 or 69·4% of the total amount. The Calumet & Hecla company heads the list with $7,000,000 followed by the Boston & Montana with $6,450,000. The Amalgamated Copper Co. paid $6,000,000 and its allied interest, the Anaconda Copper Co., paid $4,800,000. The United Verde Co. disbursed $2,325,000 and the Mountain Copper Co., Ltd., $1,200,000. Dividends from gold and silver mines amounted to $13,907,000 or 27% of the total, Stratton's Independence leading with $1,789,000. Of the metallurgical concerns the American Smelting & Refining Co. paid $2,113,803 and the National Lead Co. $1,192,000.

The Standard Oil Co. disbursed $47,800,000, and is the largest dividend payer in the United States if not in the world.

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES, $1=$1,000; TOTAL, FULL AMOUNT.

Name of Company.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Paid.
Acacia, g., Colo.									$45	$45,000
Adams, s.l., Colo.	$8			$6					8	701,000
Ætna Con., q., Cal.			$20	20	$40	$40	$40	$60	15	225,000
Ala. Con. Coal & I., pf., Ala.								44	175	218,750
Alamo, g, Utah								3		2,500
Alaska Goldfields, Alaska								125		125,000
Alaska-Mexican, g., Alaska			120	90	80	90	72	72	72	501,031
Alaska-Tread. g., Alaska	300	375	375	400	350	300	300	300	300	4,520,000
Alliance, g., Colo.								32		31,500
Amalgamated, c., Mont.								1,500	6,000	7,500,000
Amanda, g., Colo.									10	10,000
Amazon, g., Colo.									102	121,882
American, g.s.l., Colo.						36	54	60		446,000
American Agric. Chem., pref.								510	1,020	1,530,000
American Cement, Pa.								60	80	140,000
American Coal, Md.			98	105	120	120	135	150	255	982,500
American Fuel Oil, Cal.								3	12	15,000
Am. Iron & Steel, com.									34	34,000
Am. Iron & Steel, pref.								50	150	200,000
Am. Sm. & Ref., pref.								1,137	1,545	2,682,553
American Steel & Wire, com.									2,625	2,625,000
American Steel & Wire, pref.								2,800	2,800	5,600,000
American Steel Hoop, pref.								245	980	1,225,000
Am. Zinc-Lead Sm., Mo.								120	60	180,000
Anaconda, c., Mont.	13						3,000	3,900	4,800	16,950,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1892.	1993.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Paid.
Anchoria-Leland, g., Colo.					$80	$72	$72	$36		$193,000
Anderson, g., Colo.									$15	15,000
Anglo-Mexican, g., Mexico				$361	271	90	180	180		1,825,048
Apollo Con., g., Alaska						100		40	70	210,000
April Fool, g., Nev.								16		16,000
Argentum-Juniata, s., Colo.				156				42		198,000
Argonaut, g., Cal.							180	240	70	490,000
Arizona, c.s., Ariz.							405	722	576	1,464.848
Arizona Western Oil, Cal.									6	6,000
Associated, g., Colo.							50	12		84,000
Atlantic, c., Mich.						40	40		80	860,000
Bald Butte, g., Mont.	$35	$49	$172	127	38	83	98	150	83	852,148
Bethlehem Steel, Pa.								300	600	900,000
Big Four, g., Colo.									15	15,000
Bonanza Dev., g., N. Mex.								1,050		1,365,000
Boston, q., Cal.								20		20,000
Boston & Colo. Sm., Colo.								56	34	315,100
Boston-Aurora, z., Mo., pref.								29	37	66,160
Boston-California, g., Cal.								72		72,000
Boston-Duenweg, z., Mo.								32	24	56,000
Boston Get There, z., Mo.								11	9	20,250
Boston Gold-Cop. Sm., Colo.									50	50,000
Boston-Little Circle, z., Mo.								75	13	87,500
Boston & Montana, c.s., Mont.			275	1,050	1,500	1,800	1,950	5,375	6,450	20,975,000
Boston-Phila., z.l., Kas.									2	2,000
Boston-Providence, z., Mo.								11	6	17,242
Boston-S. Dak., g., S. Dak.									10	10,000
Boston-Springfield, z., Mo.									15	15,000
Boston-Sunflower, z. Mo.								5		4,500
Breece, i.s., Colo							10	40	30	100,000
Buckeye, g., Colo.									160	160,000
Buckhorn Oil, Cal.									4	3,800
Buffalo Hump, g., Idaho.									275	275,000
Bull Hill, Con., g., Colo.									15	15,000
Bull'n-Beck & Cham., g.s., Ut'h.			425	325	290	170	90	120	60	2,498,400
Bunker Hill & Sull., s.l., Ida.						102	228	201	252	1,053.000
Burlington Oil, Cal.									3	3,000
Butte & Boston, c.s.l., Mont.									1,000	1,000,000
Calumet & Hecla, c., Mich.	2,000	2,000	1,500	2,000	2,500	5,000	5,000	10,000	7,000	72,850,000
Cambria Iron, Pa.								339	339	678,000
Cambria Steel, Pa.								660	940	1,600,000
Cariboo-McKinney, g., B. C.				49	76	48	67	72	86	478,087
Cent'l-Eureka, s.g.l., Utah.	90	188	195	510	390	98	15	120	268	2,418,000
Center Creek, l.z., Mo.								10	30	40,000
Center Star, g., B. C.									35	105,000
Central, l., Mo.						28	54	60	65	207,000
Central Oil, Cal.									73	73,000
Central Oil, W. Va.									23	23,000
Champion, g., Cal.	41	41	41	27		51	26	35		402,000
Charleston, phos., S. C.							30	20		200,000
Cloverdale, z., Mo.								40	40	80,000
Colonial, l., Mo.								10		10,000
Colo. Fuel & Iron, Colo., pref.		1,203	160		160	80			800	1,160,000
Columbia, l., Mo.									17	16,975
Commodore, g., Colo.						20	20	48		432,000
Commonwealth, z., Mo., pref.								20	30	50,000
Consolidated, g., Colo.								10	110	120,000
Consolidated, z.l., Mo., pref.									8	8,000
Consolidation Coal, Md.	205	205	205	205	205	205	205	205	205	5,113,000
Con. Mercur., g., Utah.		60	200	200	200	250	355	100	225	1,591,000
Cordell, z l., Mo.								3	27	30,000
Cripple Creek Con., g., Colo.									160	160,000
Crœsus, g., Cal.							29	19	103	151,300
Crowned King, g.s.l., Ariz.							96	121		243,760
Crucible Steel, pref., U. S.									427	427,000
Daly-West, s.l.g.c., Utah								120	487	607,500
Deer Trail Con., g., Wash.								55		55,000
De Lamar, s.g., Idaho	200	450	500	450	500		48	48	48	2.394.000
Delta, l.z., Mo.								3	4	7,680
Denver & Cripple C'k, g., Colo.									11	10,625
Desloge Con., l., Mo.							20	30	20	70,000
Dewey Con., Utah.									2	4,000
Diamond Star Oil, Cal.									6	6,250
Diamond'State St., com., Del.									100	100,000
Dixie, g., Utah.									10	10,000
Doe Run, l., Mo.						30	30	60	60	412.073
Ducktown Sul., C. & I., Tenn.							29	86		136,904
Eldorado, g., Cal.								10		10,000
Elkton Con., g., Colo.			60		90	260	220	68	259	979,461
Empire State, g.s.l., Idaho.							67	256	355	672,687
Empire Steel & Iron, pref.								71	107	177,750
Fanny Rawlings, g., Colo.								20		20,000
Favorite, g., Colo.									48	48,000
Federal Steel, com.									1,743	1,743,161
Federal Steel, pref.								1,598	5,060	6,657,654

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Paid.
Ferris-Haggerty, c., Wyo.								$5		$5,000
Flat-Top C. Land Ass'n, com.									$111	278,558
Flat-Top C. Land Ass'n, pref.									149	1,949,886
Florence, s., Mont.				$35	$54	$54	$44	44	20	250,000
Frisco Con., l.s., Ida.			$15	10	50			165		920,000
Garfield Con., g., Colo.								34		34,000
Gemini, g., Utah									50	700,000
General Chem., com								129	285	414,000
General Chem., pref.								396	494	890,000
Gold Belt Con., g., Colo.									113	112,500
Gold Deposit, g., Colo.									10	10,000
Gold Coin of Victor, Colo.						120	120	210	240	600,000
Golden Cycle, g., Colo.						60	60	105	120	378,500
Golden Eagle, g., Colo.					10			10	5	25,000
Golden M. & Ext., g., Ont.								10		10,000
Golden Star, g., Ont.								46		45,500
Gold King, g., Colo.					11	25		66	112	178,000
Grafton, g., Colo.								10		10,000
Grand Central, g., Utah							219	348	25	691,250
Grand Gulch, c., Ariz.									10	9,600
Grass Valley Expl., g., Cal.								23	7	30,000
Gray Eagle Oil, Cal.									50	120,000
Greater Gold Belt, g., Colo.									76	76,000
Great Western Oil, Cal.									10	10,000
Gwin, g., Cal.						16	35	35	66	146,500
Hecla, l.s., Ida.									100	100,000
Hecla Con., s.l., Mont.	90	60	120	90	45	30		15	50	2,200,000
Helena, g., Oregon									45	45,000
Helena & Liv., S. & R., Mont.									90	90,000
Hidden Treasure, g., Cal.									29	457,452
Holy Terror, g., So. Dak.						36	81	50	5	172,000
Home, g., Colo									100	100,000
Home Oil, Cal.									200	200,000
Homestake, g., So. Dak.	150	150	256	344	375	375	636	963	1,260	9,403,750
Homestake Oil, Cal.									23	23,000
Horn Silver, g.s.l.z.c., Utah	200	230	150	50	50		80	20	20	5,270,000
Idaho, g., B. C.								28		292,000
Idaho, g., Ida.									8	8,188
Independence Con., g., Colo.									100	100,000
Iowa, g.s.l., Colo.					50	25	10		39	136,834
Iron Silver, s.l., Colo									50	2,550,000
Isabella, g., Colo.				23	180	68		270	158	697,500
Jack Pot, g., Colo.								175		175,000
Jackson, g., Cal.				2					6	6,000
Jamison, g., Cal.								12		50,700
Jeff. & Clearf. Coal, Pa., com.									30	30,000
Jeff. & Clearf. Coal, Pa., pref.							75	75	75	187,500
Kentucky I. & Coal, Ky.								11		164,041
Kern Oil, Cal.									375	375,000
Kern River Oil, Cal.									10	10,000
La Fortuna, g., Ariz.						188	238	238	238	920,500
Lake City, g., Colo.									4	3,875
Lake Superior, i., Mich.	400			84			252	84		2,132,000
Last Chance, g., B. C.							20	25		45,000
Last Dollar, g., Colo.								30	90	120,000
Lawrence, g., Colo.									10	10,000
Lehigh Coal & Nav., Pa.	861	646	574	574	574	574	574	574	789	18,517,000
Le Roi, g., B. C.								240		1,305,000
Lightner, g., Cal.									10	12,782
Lillie, g., Colo.							50	136	45	349,183
Madison, g., Colo.									35	35,000
Magnolia, g., Colo.									187	187,000
Mammoth, g.s.c., Utah.					100		200	260	200	1,790,000
Marion Con., g., Colo								5		300,000
Maryland Coal, Md., pref.		47	66	85	94	75	85	94	94	640,869
Mary McKinney, g., Colo.								30	150	180,000
Midget, g., Colo.									25	25,000
Mo. Zinc Fields, Mo., pref.								21	11	31,885
Modoc, g., Colo.						10	90	45	60	205,000
Monarch, g., Colo.									120	120,000
Monongahela R.C. & C., Pa., pref.									700	700,000
Montana Coal & Coke, Mont.									120	120,000
Montana, g.s., Mont.				205			36	99		453,700
Montana Ore Purchas., Mont.				160	320	160	160	560	240	1,660,000
Monument, g., Colo.							13	6		18,124
Morning Star, g., Cal.							82	63	7	854,400
Morse, g., Colo.								15		215,650
Mountain, c., Cal.						31	62	1,080	1,200	2,373,750
Mount Diablo, s., Nev.									5	260,271
Mount Rosa, g., Colo.					5	10	20	40		75,000
Mount Shasta, g., Cal.								6		6,000
Napa Con., q., Cal.	70	70	50	80	70	80	80	110	40	1,100,000
National Lead, com.		298	447	149			149	149	149	1,341,486
National Lead, pref.	1,043	1,341	1,490	1,192	1,043	1,043	1,043	1,043	1,043	10,579,280
National Salt, com.									245	245,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Paid.
National Salt, pref.								$175	$350	$525,000
National Steel, pref.								1,418	1,891	3,307,500
National Tube, com.									1,196	1,196,000
National Tube, pref.								700	2,800	3,500,000
New Central Coal, Md.	$50	$50	$50				$20	40	40	510,000
New Haven I. & Steel, com.								50	45	95,000
New Idria, q., Cal.						$10	70	110	60	250,000
N. J. & Mo., z., Mo.									11	11,000
N. J. Zinc.						600	600	600	1,000	2,800,000
N. Y. & Hond. Ros., s.g., C.A.						165	165	180	255	1,415,000
New York, z., Mo.								7		6,500
Nighth'k & Nig't'gale, g., Colo.									180	180,000
North Star, g., B. C.									39,000	117,000
North Star, g., Cal.								50		584,850
Oceanic Oil, Cal.									2	2,000
Old Colony, Z. & Sm., Mo.									68	68,276
Olive, g., Ont.								12		12,000
Omega, g., Colo.									18	18,188
Ontario, s., Utah.	750				180	230		15	90	13,662,500
Original-Empire, g., Cal.								100		530,000
Osceola, c., Mich.	150	100		100	125	191	277	558	558	3,657,500
Pacific Coast Borax, Cal.								100	240	762,500
Park Oil, Cal.									5	4,897
Parrot, c.s., Mont.	216	138	67				483	1,242	1,034	4,393,825
Payne, g., B. C.								50		1,053,000
Pennsylvania Coal, Pa.	800	800	1,000	800	1,500	800	800	800	800	19,700,000
Pennsylvania Con., g., Cal.							28	68	26	161,325
Penn. Salt Mfg., Pa.							150	150	300	12,550,000
Pennsylvania Steel, Pa.								26	105	131,250
Petro, s., Utah.								15		32,000
Philadelphia, Natural Gas, pref.									100	199,918
Pioneer, g., Cal.							50	13		62,500
Pittsburg Coal, Pa.									2,240	2,240,000
Plumas-Eureka, g., Cal.	51	51	51	51	25	25			84	2,797,544
Portland, g., Colo.			67	550	240	330	570	720	750	3,307,080
Producers & Cons. Oil, Cal.									53	53,000
Queen Bess Propr., g., B. C.								25		25,000
Quicksilver, q., Cal.								22	22	2,518,582
Quincy, c., Mich.	350	300	400	600	1,000	800	650	950	900	11,970,000
Rambler-Cariboo Con., g., B.C.								31	34	105,000
Raven, g., Colo.							20	50	50	119,500
Republic Con., g., Wash.							120	158	105	382,500
Republic I. & St., pref.								355	1,421	1,776,854
Reward, g., Cal.								20		20,000
Rex Oil, Cal.									26	26,000
Rocco-Homestake-Nev., s.g.l.									9	9,000
Rocky Gulch, g., Oregon.									25	25,000
Russell Irwin, z., Mo.								15		15,000
Sacramento, g.s.l., Utah.					15	15	60	50		138,000
Saint Joseph, l., Mo.	150	150	150	150		144	150	150	150	3,309,500
Santa Rita, g., Colo.									4	4,000
Shelby Iron, Ala.								130	120	250,000
Silver King, g.s.l., Utah.				263	375	450	450	625	1,000	3,450,000
Silver Shield, g.s.l., Utah.									2	1,500
Six Points, g., Colo.									120	120,000
Sloss-Sheff. I. & St., pref.									456	456,000
Small Hopes, s., Colo.							25	25		3,325,000
Smuggler, s.l.z., Colo.	150	575	50		110		120	275	360	1,730,000
Southern Boy, g., Colo.									18	17,500
Southern Cal. Oil & Fuel, Cal.									3	3,000
South Swansea, g.s.l., Utah.					20	50	38	53		165,000
Specimen, g., Colo.									153	153,347
Squaw Mountain, g., Colo.								10		10,000
Standard, s.l., Idaho.									320	2,125,000
Standard Con., g., Cal.	40	20	40	20		40	27	60	71	3,964,102
Standard Oil of N. J.								26,325	47,800	73,125,000
Stratton's Independ., g., Colo.								976	1,789	2,765,352
Strong, g., Colo.						250	300	300	300	1,045,000
Susquehanna I. & St., Pa.								180	113	292,500
Swansea, s.l., Utah.					20	50	65	65	75	276,500
Tamarack, c., Mich.	600	600	400	400	500	360	440	600	1,020	7,290,000
Temonj, g., Colo.				10					250	260,000
Tenn. C., I. & R. R., com.									451	1,102,144
Tenn. C., I. & R. R., pref.									139	238,080
Texas & Pacific Coal, Tex.								140	120	1,800,000
Tomboy, g., Colo.				300	300		50	152	144	956,000
Touraine, g., Colo.									88	87,500
Union, g., Colo.				27	13	23			313	395,244
Union, z.l., Kas.									35	35,000
United, z.l., Mo.								3	28	30,263
United States Crude Oil, Cal.									3	3,200
U. S. Oil, W. Va.								419	325	744,250
United Verde, c., Ariz.	20	435						3,000	4,499	7,861,000
Utah, g., Utah.	15	5		17	22	4		2	2	181,000
Vindicator, g., Colo.							138	178	189	493,500

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Concluded.*

Name of Company.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Paid.
Va.-Car. Chem., com					$10	$40	$40	$270	$360	$720,000
Va.-Car. Chem., pref								800	800	1,200,000
Warwick Iron & Steel, Pa								64	95	158,597
War Eagle, g., B. C							177	315	53	545,250
Weatherly-Bonanza, g., Wash								2		1,562
West Lake Oil, Cal									50	50,000
Westmoreland Coal									150	750,000
What Cheer, z., Mo								2	9	11,250
Wolverine, c., Mich							60	210	240	510,000
Wythe, l.z., Va									76	76,000
Yellow Aster, g., Cal						40	131	145	150	459,410
Ymir, g., B. C								30		30,009
Yreka, g., Cal									50	50,000
Yukon Oil, Cal								3	18	21,000
Zoe, g., Colo									8	7,500

C., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

ASSESSMENTS LEVIED BY MINING COMPANIES.

Name of Company.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Levied.
Acorn, g.s.l., Utah							$365	$760	$1,125
Ætna, g.s.l., Idaho								5,000	5,000
Ætna, g.s.l., Utah						$2,500	500		3,000
Alaska, g.s.l., Utah							34,000	20,000	54,000
Alexandria, g.s.l., S. Dak							500	500	1,000
Alhambra, s., Nev						100,000			100,000
Alliance Explor. & Mg., g., Cal								5,000	5,000
Alliance, g, Utah			$50,000				15,000	10,000	225,000
Allison-Rauch-Ford, g., Cal							5,000	10,000	15,000
Allouez, c., Mich		$16,000				80,000			1,520,930
Alpha, s., Nev	$10,000	6,000	15,750	$15,750	$8,400	8,400	3,150	3,150	322,250
Alta, s., Nev	25,200	50,400	20,160	32,400	16,200	16,200	16,200	16,200	3,697,310
Alta, g., Utah							938		938
Amelia, g., Cal								2,500	2,500
Andes, s., Nev		25,000	15,000	15,000	20,000	10,000	15,000	15,000	1,225,000
Annie, g. s., Utah								5,000	5,000
Arnold, c., Mich						180,000			180,000
Arrastraville, g., Cal						20,000	20,000	10,000	50,000
Badger, g., Oregon								10,000	10,000
Badger Hill & Cher'kee, g., Cal							60,000		60,000
Baliol, g., Cal					25,000	30,000			55,000
Belcher, s., Nev		50,200	50,200	50,200	57,000	20,800	36,400	52,000	3,603,200
Belle, g., Cal								2,000	2,000
Bellefontaine, g.s., Cal						10,000	10,000		20,000
Ben Butler, g.s., Utah							11,250	6,250	17,500
Benton Con., g.s., Nev								20,000	607,000
Best & Belcher, s., Nev	75,600	50,400	50,400	25,200	75,600	30,240	40,320	60,480	2,691,883
Biesinger & Beck, s.l.g., Utah								756	756
Bingham Placer, g., Utah							27,500	27,500	55,000
Blue Bird, g., Utah							500		500
Blue Gravel, g., Cal								10,000	10,000
Boston & Cripple C'k, g., Colo						20,000			20,000
Boulder, g., Cal						10,000	3,000	3,000	16,000
Bountiful, g.s., Utah								5,000	5,000
Brunswick Con., g.s., Cal	20,000	10,000	20,000	15,000	30,000		15,000	50,000	225,000
Buchanan, g., Cal						25,000			25,000
Buckeye, g., Utah				3,750	6,250	6,250			15,000
Buffalo Hump Dev., g., Wash								200	200
Bullion, s., Nev	25,000	30,000	40,000	20,000	20,000	15,000	10,000	5,000	3,135,000
Bunker Hill, g.s., Utah							5,000	6,250	11,250
Cadmus, g., Cal								10,000	10,000
Caledonia, s., Nev		50,000		5,000				30,000	3,270,000
California, g., Cal			4,500		1,000		2,000		19,500
California Borax, Cal								9,500	13,500
Cedar Creek, g., Cal						2,000			2,000
Centennial, c., Mich					120,000	300,000		270,000	780,000
Central Eureka, g., Cal					20,000			12,000	138,272
Central Mammoth, g., Utah								500	500
Challenge Con., s., Nev	15,000	50,000	5,000	7,500	5,000	10,000	12,500	22,500	464,500
Channel Bend, g., Cal						2,000			2,000
Chicago & Mercur, g.s., Utah							1,000		1,000
Chollar, s., Nev	61,600	56,000	56,000	28,000	44,800	50,400	28,000	39,200	2,114,800
Christmas, g.s., Utah							1,500	3,000	4,500
Church, g., Cal						3,000			3,000
Cinnabar King, g., Cal						1,000			1,000
Clarissa, g.s., Utah							5,000	5,000	10,000
Cleveland, g., Utah						2,000	1,000		3,000
Columbia, g.s., Utah						750			750
Columbus Con., g.s., Cal								2,000	2,000
Confidence, s., Nev		6,240	14,976	7,488	14,976	13,728	8,736	9,984	558,846

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Levied.
Conglomerate, g.s., Utah								$6,250	$6,250
Con. Cal. & Va., s., Nev	$6,220	108,000	$54,000	118,800	108,000	108,000	108,000	97,200	883,200
Con. Imperial, s., Nev			5,000	500	10,000	10,000	10,000	20,000	2,236,000
Con. New York, s., Nev	25,000	5,000	10,000	5,000	60,000	30,000	3,000		136,500
Con. St. Gothard, g., Cal						35,000	15,000		50,000
Constellation, g., Utah								2,250	2,250
Crown Point, s., Nev	80,000	65,000	25,000	70,000		25,000	20,000	15,000	3,005,000
Crusader Con., g.s.l., Utah								5,000	5,000
Dalton, g.s.l., Utah	3,750	5,000	5,000	5,000	2,500	7,500	5,000		58,750
Dewey Gravel, g.s.l., Cal								10,000	10,000
Dexter, g.s., Nev						30,000			38,000
Diamond Con., g.s.l., Utah							8,000		8,000
Dreisam, g., Cal							51,000	15,000	66,000
Dutch, g., Cal							22,500	52,500	75,000
Eagle, g., Oregon						3,000			6,000
El Rey, g., Utah								8,000	8,000
Ely, g., Utah							2,000	3,000	5,000
Emerald, g.s., Utah						3,000			3,000
Eureka Con., s., Nev			12,500			10,000	5,000		590,000
Eureka Con. Drift, g., Cal					75,000	5,000	15,000	17,500	213,000
Eureka-SwanseaExt.,g.s.,Utah								5,000	5,000
Eutonia, s.l.g., Utah								9,000	9,000
Excelsior Drift, g.s., Cal						667	5,000	2,000	7,667
Exchange, g.s., Utah								1,000	1,000
Exchequer, s., Nev	15,000	10,000	5,000	5,000	5,000			3,000	1,023,000
Fall River, g.s., Cal							2,500		7,500
Father de Smet, g.s., S. Dak								25,000	225,000
Fish Springs, g., Utah								1,500	1,500
Florence, g.s., Utah							1,000		1,000
Forlorn Hope, g., Cal						20,000			25,000
Four Aces, g.s., Utah					2,500	2,500	2,500	17,500	22,500
Fremont, g.s., Utah								2,500	2,500
Frisco, g.s., Utah							2,000	2,000	32,000
Galata, g., Cal						10,000			10,000
Galena, g., Utah						10,000			10,000
Galena Treasure, g.s., S. Dak							200	200	400
Garden City, g.s., S. Dak								563	7,105
Garibaldi, g.s., Cal							4,000	4,000	8,000
Genevieve, g.s., Utah							5,000		5,000
Gerrymander, g.s., Cal							10,000	5,000	15,000
Geyser, s.l., Colo						50,000	200,000		1,275,000
Geyser-Marion, g.s., Utah								9,000	9,000
Gold Coin (Gilpin Co.), Colo							10,000		10,000
Golden Channel, g., Cal							3,000	2,500	5,500
Golden Eagle, g.s., Nev							4,000		4,000
Golden King g., Cal						3,500			3,500
Golden Star, g.s., Cal							2,000	1,500	3,500
Gold Hill, g.s., Cal								25,000	25,000
Gold Hill, g.s., Utah								500	500
Gold Leaf, g.s., Wash							100		100
Gold & Silver Carb., g.s., Utah							2,500		2,500
Goleta Con., g., Cal								63,000	63,000
Gonyon, g.s., Utah								2,500	2,500
Good Title, g., Cal						20,000			20,000
Gould & Curry, s., Nev	80,200	32,400	48,600	48,600	59,400	37,800	49,400	54,800	4,743,250
Granite Hill, g.s., Cal							3,000		124,000
Grape Vine Canyon, g.s., Cal							10,000	14,000	24,000
Great Bonanza, g.s., Utah								5,000	5,000
Great Eastern, g.s., Utah						1,500	1,500	1,500	4,500
Great Western, q., Cal						5,000	20,000		75,520
Grizzly, g.s., Cal						1,500		5,000	6,500
Hale & Norcross, s., Nev							39,200	22,400	5,739,880
Head Center Con., g.s.c., Ariz							25,125		25,125
Hercules, g.s., Utah								20,000	20,000
Hester A., g.s., S. Dak								500	3,000
Highland(Leadville),g.s.,Colo								125,000	125,000
Highland, g.s., Utah								8,000	8,000
Hilda Gravel, g.s., Cal						2,000		2,000	4,000
Hillside, g.s., Utah							1,500		1,500
Himalaya, g.s., Utah							5,000		15,000
Home, g.s., Cal						3,000		10,000	13,000
Homestake, g.s., Utah						4,000	4,000		12,000
Horn Silver Tunnel, g.s., Utah							500	500	1,000
Horsefly, g., Cal						8,000			8,000
Horseshoe Bar Con., g.s., Cal						6,000	3,000	1,200	87,000
Humboldt, g.s., Cal							2,000		2,000
Independence, g.s., Utah							6,000	9,000	15,000
International, g.s., Utah							1,500		1,500
Jefferson, g.c., Utah								1,500	1,500
Jennie Lind, g.s., Cal							1,000	2,000	3,000
Joe Bowers, g.s., Utah								14,000	14,000
Joe Bowers Ext., g.s., Utah								15,000	40,500
Julia Con., s., Nev	5,000		5,500	5,500	5,500		3,300	3,300	1,501,800
Jumbo, g.s., Utah						500			500
Junction, g.s., Cal						10,500	6,000		16,500

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Levied.
Jupiter Gravel, g., Cal.					$40,000	$40,000			$80,000
Justice, s., Nev.						10,500	$21,000	$15,750	3,683,500
Karan, g., Cal.						2,500			2,500
Kate Hayes, g.s., Cal.						10,000	10,000		70,000
Kentuck, g., Utah						30,000			30,000
Kentuck Con., s., Nev.	$10,500	$26,250	$10,500	$5,250	10,500	5,250		3,150	128,450
Lady Washington, s., Nev.				5,400			5,400		163,200
La Grange, g.s., Cal.							15,000		15,000
Laird, g., Cal.						10,000			10,000
Larkin, g.s., Cal.						2,000	2,000	4,000	18,000
La Suerte, g.s., Cal.						7,500	7,500	7,500	22,500
Leon, g., Cal.						1,500			1,500
Lion Con., g.s., Utah							500	500	1,000
Little Chief, g.s., Utah							8,000	12,000	20,000
Little Pittsburg, g.s., Utah			4,000	6,000	4,000	4,000	5,000		23,000
Live Oak Con., g.s., Cal.						20,000	10,000	10,000	40,000
Live Yankee, g.s., Cal.						5,000	2,000		7,050
Lower Mammoth, g.s., Utah						12,500	15,000	15,000	42,500
Lucky Bill, g.s., Utah				7,200	6,600	1,800	2,500	2,400	61,300
Lulah Con., g.s., Utah							1,500		1,500
Madge, g.s., S. Dak.							200		200
Mammoth Garfield, g.s., Cal.								17,500	17,500
Marguerite, g.s., Cal.					20,000	15,000	15,000		85,000
Marina Marsicano, g.s., Cal.					16,360	19,000	19,000	7,000	61,360
Mariposa Com'l&M'g,g.s.,Cal.								50,000	160,000
Marmaduke, g.s., S. Dak.								500	500
Martha Washington,g.s.,Utah						3,000	6,000	6,000	15,000
Martin White, s., Nev.	25,000	25,000					120,000		1,440,000
Maxfield, g.s., Utah						6,000	9,000	9,000	24,000
Mayday, g.s., Cal.						5,000	10,000	5,000	20,000
Mayday, g.s., Utah						2,000	2,000		4,000
Mayflower Gravel, g.s., Cal.						6,000		7,500	13,500
Mayflower, g.s., Utah								2,000	2,000
Mazeppa, g.s., Cal.								5,000	5,000
Melcher, g.s., Utah								2,000	2,000
Merrimac, g., Cal.						20,000			20,000
Meteor, g.s., Utah						3,734	4,999	2,997	11,710
Mexican, s., Nev.	76,500	75,600	75,600	40,320	20,000	40,320	25,200	45,360	2,359,520
Midland, g.s., Utah								3,000	3,000
Midnight Bowers, g.s., Utah							1,000	1,000	2,000
Molly Bawn, g.s., Utah							1,000		1,000
Montecito, g., Cal.						10,000			10,000
Montreal, g.s., Utah			375		375		25,000		30,625
Mooney Con., g.s., Cal.								20,000	20,000
Morgan, g., Cal.						10,000			10,000
Mountaineer, g.s., Cal.						15,000		25,000	40,000
Murray Hill, g.s., Utah						250	250		500
Nancy Hanks, g., Cal.						5,000			5,000
Nashville, g., Cal.						2,000			2,000
National Con., g.s., Cal.						15,000	45,000	15,000	68,685
Nevada, s., Nev.								10,000	10,000
New Erie, g.s., Utah							2,000	500	2,500
New Imperial, g.s., Utah							1,000		1,000
New Klondike, g.s., Utah							2,961	235	3,196
New La Plata, g.s., S. Dak.								300	1,700
New State, g.c., Utah								1,500	4,500
North Bloomfield, g., Cal.						25,000			25,000
North Bonanza, s., Nev.								15,000	255,000
North Gould & Curry, s., Nev.	10,000	20,000		10,000		20,000			375,000
North Mercur, g., Utah						10,000			10,000
North Rapidan, s., Nev.								8,000	8,000
Northern Light, g.s., Utah						8,000		8,000	16,000
Northern Spy, g.s., Utah						10,000	10,000		20,000
Occidental Con., s., Nev.	55,000	30,000	30,000	65,000	30,000	20,000	20,000	5,000	524,179
Okanogan, g., Wash.								10,566	10,566
Old Bonanza, g.s., Cal.							2,500		2,500
Old Colony&Eureka,g.s.,Utah								2,500	2,500
Old Home, g.s., Cal.						5,000	3,500	3,500	12,000
Old Susan, g.s., Utah								7,500	7,500
Omaha Con., g.s., Cal.						10,000	25,000	100,000	135,000
Omaha, g.s., Utah								6,000	6,000
Ophir, s., Nev.	100,000	100,000	100,000	25,200	25,200	43,200	50,400	60,480	4,713,448
Opohonga, g.s., Utah						1,500	1,000		2,500
Orient, g.s., Cal.							50,000	75,000	125,000
Orleans, g.s., Cal.						15,000	12,000		17,000
Oro Quartz, g.s., Cal							4,500		4,500
Osceola Con., g.s., Cal.						1,000	1,000	2,000	13,810
Overman, s., Nev.	60,000	34,560	23,040	34,560	17,280	17,280	11,520	17,268	4,158,390
Pacific, g.s., Utah							500	750	1,250
Palo Alto, g.s , Wash.						100	200		200
Park City & Mid. Sun, Utah								10,000	10,000
Peabody, g.s., Cal.								10,000	10,000
Phœnix, g.s., Utah					1,000			1,000	2,000
Picnic, g.s., Utah								1,000	1,000
Potosi, s., Nev.	84,000	112,000	56,000	28,000	50,400	50,400	39,200	39,200	2,235,660

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Concluded.*

Name of Company.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total Levied.
Powning, g.s., Cal							$2,500		$2,500
Prior Hill, g.s., S. Dak								$200	1,000
Quincy, g., Cal							10,000	20,000	30,000
Red Cap, g., Cal						$90,000			90,000
Reddick, g.s., Cal						5,000	5,000		10,000
Red Jacket, s., Nev							2,000		2,000
R. G. W., g.s., Utah							2,000	1,000	3,000
Rescue Gold, Nev					$3,000	2,000	500		5,500
Reservation, g.s., Wash							100		700
Revenue, g.s., Utah							4,500		4,500
Reward, g.s., Cal					7,040	3,840	3,200	9,920	77,000
Rich Bar Gravel, g.s., Cal								6,000	6,000
Richmond, g., Cal						10,000			10,000
Ridge & Valley, g.s., Utah								5,000	5,000
Rockland, g., Cal						3,000			3,000
Rose Creek, g.s., Cal						5,000	5,000		10,000
Ruby Hill, g.s., Utah								600	600
Sacramento, g.s., Utah							600		600
Sailor Con., g.s., Cal							11,000	6,000	17,000
Salmon River, s., Nev							1,425		11,970
Salt Lake & Nev., g.s., Utah						1,000			1,000
Santa Rosalia, q., Mex								5,000	5,000
Savage, s., Nev	112,000	100,805	$67,200	$67,200	67,200	44,800	22,400	33.600	7,343.600
Scorpion, s., Nev		5,000			5,000			3,000	448,000
Seg. Belch. & Mides, s., Nev	35,000	20,000	30,000	10,000	10,000	8,000	10,000	6,000	384,000
Sheba, g.s., Cal								10,000	10,000
Sheep Rock, g.s., Utah					5,250			52,500	57,750
ShoebridgeBonanza,g.s.,Utah								3,200	9,600
Shower Con., g.s., Utah							8,000	2,000	10,000
Sierra Nevada, s., Nev	45,000	50,000	50,000	50,000	40,000	20,000	50,000	45,000	6,801,910
Silver Bell, s., Mont						5,000			5,000
Silver Bow, g.s., Utah								5,000	5,000
Silver Cloud, g.s., Utah							5,000		5,000
Silver Hill, s., Nev	5,400	5,400			5,400	5,400			2,220,200
Silver King, g.s., Ariz		100,000		75,000	50,000	50,000	50,000	25,000	490,000
Silver Park, g.s., Utah								9,000	9,000
Silver Queen, g.s., Utah								1,000	1,000
Silver State, g.s., Utah					1,000			500	1,500
Siskiyou Con., g.s., Cal	9,000	14,000	4,000	2,000		3,000	3,000	6,000	55,000
Skagit Cumb. Coal, Wash								7,500	7,500
Snow Flake, g.s., Utah						2,000	5,000	2,000	21,500
Sonora Quartz, g.s., Mex								5,000	5,000
South Bingham, g.s., Utah							2,500	2,500	5,000
South Eureka, g.s., Cal							6,000		6,000
South Fork Con., g.s., Utah						5,000			5,000
South Paloma, g.s., Cal								1,200	1,200
Spanish Bar, g.s., Cal						2,000	5,000	11,000	18,000
Star, g.s., Utah						5,000	30,000	25,000	60,000
Sterling, g., Cal						15,000			15,000
Success, g.s., Utah							9,750	3,000	12,750
Sunbeam Con., g.s., Utah					11,250	5,000	50,000	55,000	131,383
Sweet Vengeance, g.s., Cal								10,000	130,000
Tanama, g.s., Cal							10,000		10,000
Tesora, g.s., Utah								2,750	2,750
Tetro, g.s., Utah						18,000	15,000	15,000	51,000
Texas, g.s., Cal							15,000	30,000	45,000
Thorpe, g s., Cal						5,000	5,000		10,000
Tintic, g.s , Utah							4,375		4,375
Tracy, g.s., Cal							5,000		5,000
Trinity, g., Cal						1,000			1,000
Triumph, g.s., Utah							1,000		1,000
Troy, g.s., Alaska					2,000	6,250	6,250		16,750
Tuscarora Chief, g.s., Utah							2,000		2,000
Union Con., s., Nev	45,000	35,000	20,000	40,000	20,000	30.000	18,000	30,000	2,690,000
U. S. Grant, g.s., S. Dak								1,000	4,500
Utah Con., s., Nev	25,000	5,000	5,000	10,000	30,000	20,000	15,000	15,000	500,000
Valeo, g.s., Utah							10,000	10,000	20,000
Vallejo, q., Cal						2,000	2,000		4,000
Victor, g.s., Utah				375				15,000	15,000
Victoria, g.s., Utah								4,000	4,000
Victory, g.s., S. Dak								200	2,825
Washington Con., g.s., Wash								200	2,000
Watt Blue Gravel, g.s., Cal							3,000		58.000
West Morn'g Glory, g.s., Utah								1,250	5,000
West M't'n Placer, g.s., Utah								8,000	8,000
West Park & Swansea, Utah								500	500
Willow Creek, g.s., S. Dak							1,100		1,100
Yankee Con., g.s., Utah							2,500	5,000	7,500
Yankee Girl, g.s., Utah							5,000		5,000
Yellow Jacket, s., Nev	90,000	90,000	90,000	90,000		24,000	36,000	42,000	5,868,000
Young America, g.s., Utah								8,000	8,000
Yuba River, g., Cal						2,500			2,500
Zuba, g., Cal						5,000			5,000

C., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

GENERAL SUMMARY OF THE IMPORT DUTIES OF THE PRINCIPAL COUNTRIES IN THE WORLD.

Substance.	Austria Hungary. 100 kg. or ad. val.	Canada Ad. val. Tons and lb.	Chile. Ad. val.	China. 133⅓ lb.	France. 100 kg.	Germany. 100 kg.	Italy. 100 kg.	Japan. 133⅓ lb. ad. val. Tons.	Mexico. Kg.	Russia. 36.112 lb	Spain. 100 kg.	Sweden 100 kg.	United States. Ad. val. Tons and lb.
	$	$	$	$	$	$	$	$	$ Mex.	$	Pesetas	$	$
Alum	0·609	Free.	5%	0·0315	0·965	0·714	0·193	0·099	0·25		1·80	0·335	0·005 lb.
Aluminum, crude	Free.	Free.	Free.		38·60	Free.	0·97	Free.	0·25	1·93	2·00	Free.	0·08 lb.
M'f'res		(1)25%	25%		38·60	14·28	19·30		0·25	2·393	48·75		45%
Antim'ny, ore	Free.	Free.	Free.		Free.	Free.	Free.	Free.	Free.	0·15	0·30	Free.	Free.
Metal	Free.	Free.	25%		1·155		1·16	5%	0·25	0·23	2·00	Free.	0·0075 lb
Arsenic	0·203	Free.	25%	0·315	Free.		0·193		0·25	0·41	12·00	Free.	Free.
Arsenious acid	0·203	Free.		0·315						0·41			Free.
Asbestos, crude	Free.	Free.	5%			Free.			0·01	0·10		Free.	Free.
M'f'res	(2)	30%	5%			(3)		10%		0·46		Free.	25%
Asphalt	Free.	Free.	Free.		Free.	Free.	0·10		0·04	(4)0·077	0·60	Free.	3·00 t.
Barytes			Free.			Free.	0·39						0·75 t.
Borax, crude		Free.	25%		Free.	Free.	0·10	0·619		0·62	12·00		0·05 lb.
Refined	1·218	Free.	25%		1·93	Free.	0·10	0·619		0·93	12·00		0·05 lb.
Cement	1·218	(a)0·125	5%	5%	(5)0·096		0·10		(b)0·50	0·10		0·161	(a)0·08
Coal	Free.	(6)Free.	Free.	0·126		Free.	Free.	0·44 t.	Free.		3·00		(6) Free.
Coke	Free.		25%	0·105	0·023	Free.	Free.	0·395 t.	Free.		3·00		20%
Copper, pigs, ingots	Free.	Free.	Free.	0·70	Free.	Free.	0·77	5%	0·10	1·828	(7)	Free.	Free.
Bars, sheets	(8)3·25	Free.	Free.	1·35	2·509	2·856	2·70	1·54	(9)0·12	2·39	(7)	1·34	0·25
Wire	(8)3·25	15%	Free.		2·509	2·856	3·86	3·75	0·20		48·00	2·68	45%
Copper sulphate	Free.	Free.	(10)15%		0·772		0·39			0·772	1·20	10%	0·005 lb.
Copperas		Free.	Free.	0·07	0·193		0·39			0·17	1·80	10%	0·0025 lb
Fluorspar	Free.		Free.			Free.	Free.						
Graphite, crude	Free.	10%	Free.		Free.		Free.		0·08			Free.	Free.
M'f'res	0·406	25%	25%										Free.
Hydrochloric acid	0·203	20%	25%		0·071		0·193			0·343	2·60	Free.	35%
Iron, pig	0·325	2·50 t.	Free.	0·05	0·386	(11)0·238	0·53	0·042	0·01	0·232	2·40	Free.	4·00 t.
Bars	1·117	7·00 t.	Free.	0·087	0·965	0·595	(12)1·16	(13)0·178			11·40	0·67	0·006 lb.
Sheets and plates	(14)1·624		Free.	0·087	(14)1·447	0·714	1·74	0·197	0·04		(15)15·60	(16)1·07	
Steel, ingots	1·116	2·00	Free.	0·175	0·965	0·595	0·53	0·042	(b)0·50	0·417	6·00	0·54	(17)
Rails	1·116	30%	Free.	0·175	1·351	0·595	1·16	0·149	Free.	0·463	7·20	Free.	0·0035 lb
Tin plates	1·624	Free.	Free.	0·28	(18)2·89	1·19	(19)2·70	0·346	(20)0·01	1·312	24·00	Free.	0·015 lb.
Lead in pigs	0·812	15%	Free.	0·175	(21)0·77	Free.	0·10	0·184	0·05	0·077	2·00	Free.	0·02½ lb
Sheets, pipes wire	2·030	35%	Free.	0·385	1·35	0·713	0·58	9·38	0·05	0·232	2·00	Free.	0·025 lb.
Mangan. ore	Free.	Free.	Free.		Free.	Free.	Free.			0·054	0·30	Free.	(22)Free
Nickel, crude	Free.	(23)10%	25%		Free.		Free.	1·765	0·25	1·828	2·00		0·06 lb.
Bars, sheets		Free.	25%	5%	2·509		1·93	1·765		2·393	2·00		0.06 lb.
Petroleum, crude	1·42	(c)0·025	Free.	Free.	(d)1·737	1·428	1·54		0·02	0·154	25·00	Free.	Free.
Refined	2·03	(c)0·05	25%	Free.	(d)1·93	1·428	9·26	(c)0 008	0·01	0·772	40·00	Free.	Free.
Pyrites	Free.		Free.		Free.	Free.	Free.			0·008		Free.	Free.
Quicksilver	Free.	Free.	Free.	1·40	Free.	Free.	1·93	2·84	Free.	1·853	2·00	Free.	0·07 lb.
Salt	(24)0·34	(25)0·075	(26)0·036	Prohib.	(27)0·46		Prohib.		0·02		3·90	Free.	(28)0·12
Slate, roofing	0·41	25%	Free.	Free.	0·266	0·12			0·01	0·077			20%
Soda	0·325	Free.	25%		(29)0·44	(29)0·36	0·10		0·03	0·415	4·55	Free.	0·002 lb.
Nitrate		Free.	25%		Free.		(29)Free	0·24	0·01	Free.	1·20		Free.
Sulphur	Free.	Free.	25%	(24)	(30)Free		Free.		0·01	0·015	1·50	Free.	(30)Free
Sulph'ric acid	0·304	25%	25%		Free.		0·10			0·17	2·60	0·14	(31)Free
Tin in blocks or pigs	Free.	Free.	Free.	0·875	Free.	Free.	Free.	0·996	0·12	0·348	15·00	Free.	Free.
Bars, plates, sheets	2·03	Free.	Free.		1·158	1·428	2·90		0·25				
Zinc, blocks, pigs	0·406	Free.	Free.	0·175	Free.	Free.	Free.	5%	0·01	0·386	6.00	Free.	0·015 lb.
Sheets and plates	1·218	Free.	Free.		0·772	0·714	0·77	10%	0·07	0·772	18·00	Free.	0·02 lb.
M'f'res	2·03	25%	35%		2·316	(40)1·43	2·32		0·25		33·80		
Zinc white	1·218	5%	25%		5%	4·76	0·97	0·615		0·463			0·01 lb.

¶ NOTE.—The United Kingdom exacts no import duties on the above substances.
(a) Per 100 lb. (b) Per 100 kg. (c) Per gallon. (d) Per hectoliter. (1) Hollow-ware, 30%. (2) Paper, unformed, $2·03 per 100 kg.; paper, formed, $4·872 per 100 kg. (3) Yarn, string and cordage, $5·712 per 100 kg.; tissue, $9·52 per 100 kg.; other articles, $14·28 per 100 kg. (4) Crude only. Ground asphalt, $0·1108. (5) Portland cement, $0·1447. (6) Anthracite only. Bituminous coal, $0·53 per ton in Canada and $0·67 per long ton in the United States. (7) Copper of first fusion, 15·00 pes.; in bars and ingots, 27·00 pes.; in sheets and rails, 42·00 pes. per 100 k. (8) Plates, sheets and wires less than 5 mm. in section, $4·06 per 100 kg. (9) Bars only. Copper sheets and plates, $0·15 per kg. (10) Unrefined. (11 Iron for purpose of being wrought, $0·595 per 100 k. (12) Rods. plates and bars more than 7 mm. in section. Material 5·7 mm. in section, $1·35; less than 5 mm., $1·74. (13) Bars and rods more than 0·25 in. in section. Bars and rods 0·25 in. or less in section, $0·333. (14) Sheets more than 1 mm. thick. (15) Plates more than 3 mm. thick, 12·85 pes. (16) Plates more than 3 mm. thick, $0·804. (17) Duty varies from $0·003 to $0·047 per lb. (18) Plates less than 6 mm. thick. (19) Plates more than 1·5mm. thick. (20) Plates more than 55 cm. in length or 40 cm. in breadth, $0·07. (21) Containing less than 25 g. silver per 100 kg. (22) Less than 50% Mn, $0·40 per ton. (23) Nickel anodes. (24) Can be imported only by special permission. (25) Duty per 100 lb. in package. Salt in bulk pays $0·05 per 100 lb. (26) Duty per kg. of refined salt. (27) Crude salt. Refined salt pays $0·5848 per 100 kg. (28) Per 100 lb. salt in package. Salt in bulk pays $0·08 per 100 lb. (29) Crude soda. (30) Unrefined. (31) Not exceeding 1·38 sp. gr. (32) Coarse wares.

AUSTRALASIA.

THE most important articles of mineral production in the seven colonies of Australasia are gold, silver, lead, copper, tin, iron and coal. These industries are referred to specifically under the respective captions elsewhere in this volume. The statistics of production, imports and exports as reported in the official statistics are summarized in the following tables:

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*) (*c*) (IN METRIC TONS AND DOLLARS; £1=$5.)

Year.	Alunite.		Antimony and Ore.		Bismuth.		Chrome Ore		Clay. (Fire.)		Coal.		Cobalt Ore.		Coke.	
1895....	845	$16,640	486	$36,255	...		4,297	$65,240	20	$275	3,798,325	$5,476,635	6	$130	28,072	$123,415
1896....	1,393	20,580	135	9,170	41	$2,450	3,913	56,400	35	345	3,972,068	5,627,405	...		26,773	109.255
1897....	736	10,860	172	18,060	3	4,000	3,433	51,345			4,453,729	6,150,205	...		65,229	226,960
1898....	2,988	44,115	84	4,580	30	23,075	2,145	31,505	15	160	4,781,551	6,359,163	119	2,800	83,538	324,674
1899....	935	13,815	332	13,470	16	16,775	5,327	87,080	27	330	4,670,580	6,628,995	193	4,495	98,074	385,650

Year.	Copper Ingot.		Copper Ore and Regulus.		Gold—Kg.		Iron. (*b*)		Iron Oxide		Lead, Argentiferous.		
											Metal	Ore.	Value.
1895....	2,838	$596,500	1,075	$107,925	11,202·6	$6,579,646	2,442	$78,100	155	$1,740	30,162	193,266	$7,805,050
1896....	4,524	1,001,180	15	375	9,221·2	5,366,800	4,798	166,415	381	4,005	19,886	271,640	8,794,665
1897....	6,864	1,499,145	109	4,255	9,088·9	5,442,065	3,291	109,310	234	2,680	18,395	275,249	8,407,640
1898....	5,744	1,400,240	181	4,195	10,590·4	6,223,649	5,283	211,250	398	4,160	10,270	394,676	8,223,885
1899....	4,715	1,650,600	1,358	348,470	15,433·3	8,759,075	6,604	277,500	402	4,230	20,614	431,126	9,968,720

Year.	Lead, Pig.		Manganese Ore.		Opal—Kg.		Platinum. Kg.		Shale, Oil.		Silver—Kg.		Stone.	
													Limestone Flux	
1895....	20	$985	3	$50	153·3	$30,000			60,377	$376,095	17,112	$409,290	105,861	$340,800
1896....	24	1,295	..		630·4	125,000	75·8	$17,395	32,348	171,010	6,307	132,590	90,346	271,305
1897....	32	1,990	..		2400·4	475,000	61·2	14,745	34,635	203,060	4,666	83,555	68,671	208,990
1898....	1,745	96,410	1	25		400.000	38·9	10,310	30,164	159,170	16,580	296,390	9,401	28,915
1899....	(*d*) 4,896	498,945	*Nil*			675,000	19·8	5,350	37,307	204,115	21,525	384,565	1,016	3,750

Year.	Tin, Ingot.		Tin Ore.		Zinc Ore.		Sundry Minerals
1895....	2,235	$680,400	78	$12,715			$23,185
1896....	1,737	496,060	98	14,525			4,620
1897....	1,159	350,640	14	2,800	29,303	$118,440	37,160
1898....	908	302,825	1	175	39,564	144,705	10,105
1899....	835	496,690	5	1,450	50,677	246,035	24,850

(*a*) From the Annual Report of the Department of Mines and Agriculture, New South Wales, 1897. (*b*) Manufactured from old iron. (*c*) In addition to the above there is a small output of diamonds, which amounted to 56,352 cts. ($156,965) for the ten years preceding 1898. (*d*) Includes carbonate and chloride.

MINERAL IMPORTS OF NEW SOUTH WALES. (*a*) (*c*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Brass. (Yellow Metal.)	Cement—*Barrels.*		Chrome Ore.		Coal.		Coke.		Copper. In Matte and Regulus.	
1895....	$80,525	162,621	$330,760	3,840	$66,705	378	$1,870	43,206	$134,160	94	$19,155
1896....	92,895	126,242	239,025	5,537	109,920	807	4,870	43,824	675,535	93	19,380
1897....	69,290	184,831	403,210	2,731	49,240	1,755	6,065	33,970	511,980	42	8,680
1898....	102,250	183,851	418,580	4,780	82,770	666	2,985	4,064	61,735		
1899....	130,165	247,393	622,245	4,009	63,380	2,453	6,520	433	8,020	91	16,755

Year.	Copper—*Continued.* Ingot.		Ore.		Rod, Sheet, and Wire.	Gold. Coin.	Bullion and Ores.	Iron and Steel. Pig.		Ore.		Manufactures.	
1895....	246	$50,480	379	$20,620	$11,400	$279,225	$10,052,150	6,568	$98,055	1,522	$6,945	55,004	$2,642,300
1896....	5	1,085	315	12,875	27,895	2,407,100	9,943,755	8,195	124,255	103	555	67,978	3,626,075
1897....	6	1,585	1,401	92,440	96,445	5,749,095	10,328,540	16,256	269,470	1,293	8,095	71,469	3,904,105
1898....	3	1,000	1,013	40,245	61,635	18,523,980	9,779,270	12,681	189,885	2,638	8,525	65,140	3,621,285
1899....	43	11,560	9,209	346,500	27,074	3,510,800	12,908,555	9,153	168,395	4,205	14,615	89,957	5,224,515

Year.	Lead. Pig.		Pipe, Sheet and Old.		Nickel Ore.		Petroleum, Refined. *Liters.*	Potassium Salts. Nitrate.		Quicksilver. *Flasks.*		
1895....	4,775	$224,330	18	$1,955	317	$9,865	9,726,209	396,125	138	$15,410	797	$29,595
1896....	7,440	362,720	268	19,720	3	120	9,538,367	438,375	162	19,905	261	9,250
1897....	5,281	289,590	303	20,235	203	5,000	11,027,291	492,275	176	18,455	470	12,255
1898....	2,379	135,330	49	3,685	788	7,575	13,723,963	563,690	181	17,170	469	17,005
1899....	1,963	125,580	75	6,145	(*b*)		17,335,661	883,255	114	11,115	398	17,010

Year.	Salt. Rock.		Brine. *Bags.*		Silver. Coin.	Ingot—Kg.		In Matte—Kg.		Ore.		Slate. Roofing—*Number*	
1895....	10,811	$70,515	26,956	$223,810	$109,470	95	$1,945	503	$10,110	922	$63,275	954,449	$30,635
1896....	7,275	39,825	25,784	207,560	49,000	180	3,900	3,958	79,245	15,073	672,770	2,219,681	90,595
1897....	4,654	34,110	36,722	261,230	131,630	288	5,060	1,928	35,500	1,288	38,680	1,908,475	78,990
1898....	8,647	59,220	30,901	217,115	286,010	267	4,980			964	37,625	1,893,871	90,240
1899....	7,987	46,430	34,537	231,740	354,185	299	5,975	1,045	18,715	3,070	95,045	2,835,637	113,690

Year.	Slate—*Cont'd.* Slabs. *Number.*		Sodium Salts. Bicarbonate.		Carbonate. (Crude.)		Carbonate. (Crystals.)		Hydrate. (Caustic.)		Stone, Excepting Marble.
1895....	2,150	$7,405	636	$24,520	1,068	$27,370	1,164	$24,895	850	$46,985	$69,140
1896....	3,602	11,675	611	25,080	1,749	60,300	745	18,305	1,010	48,465	40,925
1897....	2,605	8,575	788	31,395	1,452	50,583	495	7,940	1,213	66,900	27,065
1898....	3,482	12,430	953	36,495	1,469	38,905	468	13,440	1,241	63,225	30,235
1899....	5,307	13,135	1,200	39,080	1,716	42,525	566	19,375	1,209	61,680	31,065

Year.	Sulphur.		Tin. Ingot.		Ore.		Plates.	Zinc. Slabs.		Sheet and Manufactures.	
1895....	1,728	$32,800	946	$272,700	1,493	$270,980	$372,870	693	$53,880	320	$28,110
1896....	1,330	22,235	910	265,505	1,073	169,875	353,345	1,416	116,115	368	35,500
1897....	2,287	33,955	693	205,135	662	104,510	200,350	1,341	122,815	561	58,010
1898....	1,845	26,960	478	161,245	554	92,665	373,060	1,220	122,325	377	43,905
1899....	1,575	23,575	681	396,095	868	262,455	258,035	724	90,720	225	35,005

(*a*) From the *New South Wales Statistical Register.* (*b*) Not stated in the reports. (*c*) In addition there were exports of manufactures for which no weights are stated; in 1895, $142,035; 1897, $68,495; 1898, $136,640; 1899, $86,690.

MINERAL EXPORTS OF NEW SOUTH WALES. (*a*) (*e*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony. Ore.		Auriferous.		Metal.		Bismuth Ore.		Cement. *Barrels.*		Chrome Ore.	Coal.		Cobalt Ore.		
1895..	225	$9,945	209	$19,850	44	$6,460	0·6	$210	10,279	$23,275	8,151	$140,535	2,200,890	$3,869,770	235	$7,265
1896..	87	2,810	25	3,160	23	3,200	45·0	3,350	33,987	74,650	9,465	145,165	2,514,506	4,501,320	284	9,750
1897..	49	2,510	21	1,500	102	14,050	*d*3·3	4,150	15,272	39,185	5,959	101,320	2,739,769	4,760,270	73	2,500
1898..	57	2,2150	13	795	13	1,570	31·5	23,775	16,801	45,420	6,924	122,775	2,836,465	4,813,340	184	4,450
1899..	314	11,820	18	1,650	1	20	15·8	16,775	12,297	36,030	9,795	167,930	2,843,310	5,028,970	347	11,095

Year.	Coke.		Copper. Ingot.		In Matte.		In Regulus.		Ore.		Rod, Sheet, Wire.	Gold. Ore.	Coin.
1895....	8,948	$42,625	2,926	$619,730	194	$37,710	1,086	$115,925	55	$1,730	$3,370	$946,845	$13,552,800
1896....	5,521	22,615	4,026	904,540	595	117,595	(c)		15	375	3,000	488,425	18,014,930
1897....	32,221	135,225	4,126	964,880	2,778	549,440	(c)		169	4,255	5,770	282,040	21,733,235
1898....	31,284	125,330	5,285	1,285,715	460	114.765	(c)		181	4,195	12,950	227,410	32,645,300
1899....	43,706	181,980	5,532	1,936,700	1,163	397,660	(c)		482	17,710	21,245	13,970	17,446,430

Year.	Gold—*Continued.* Bullion—Kg.		Iron and Steel. Pig Iron.		Manufactures. (b)		Lead. Pig.		Pipe and Sheet.		Argentiferous.		Nickel Ore.	
1895....	3,758	$2,174,985	201	$3,825	14,504	$726,680	2,737	$131,400	577	$39,945	30,162	$4,798,680	343	$9,175
1896....	2,576	1,417,520	1,470	26,350	17,289	1,039,375	3,150	167,425	750	52,535	19,897	3,974,335	(c)	
1897....	3,295	2,043.690	1,183	22,495	19,515	1,297,320	2,100	119,395	1,043	77,725	18,395	3,227,385	203	4,900
1898....	3,326	2,022,925	1,294	31,060	15,454	1,021,015	3,367	191,210	707	57,945	10,271	1,605,680	785	9,800
1899....	7,309	4,614,655	639	12,785	16,550	1,176,695	4,865	333,235	1,339	125,160	20,582	2,023,640	71	840

Year.	Salt. Rock.		Brine—*Bags.*		Silver. Coin.	In Matte—Kg.		Ore.		Sodium Salts. Bicarbonate.		Carbonate. (Crude.)	
1895....	855	$7,995	3,999	$46,035	$38,330	5,855	$118,190	194,158	$3,068,985	56	$2,500	175	$5,800
1896....	457	3,605	2,820	32,440	66,450	7,550	152,960	284,524	5,447,925	39	1,790	207	7,010
1897....	330	3,065	4,752	58,380	99,545	2,454	41,860	275,807	5,205,525	61	2,795	117	4,010
1898....	433	3,635	5,166	60,445	149,360	8,794	152,655	396,057	6,684,955	124	5,580	285	9,595
1899....	315	2,520	5.491	59,935	312,475	17,583	312,665	432,520	7,901,180	105	3,915	139	4,145

Year.	Sodium Salts—*Continued.* Hydrate. (Caustic.)		Nitrate.		Stone.	Sulphur.		Sulphuric Acid.		Tin. Ingot.		Ore.		Plate.
1895....	67	$1,000	17	$2,480	$4,705	42	$2,105	247	$19,430	3,181	$970,410	80	$12,955	$87,445
1896....	148	7,545	6	790	7,015	139	4,240	100	5,535	2,646	763,595	99	14,525	79,100
1897....	90	4.660	42	5,730	3,545	32	1,300	52	3,495	1.837	556,345	143	2,800	78,205
1898....	132	6,530	37	4,365	3.505	38	1,565	24	1,390	1.384	481,925	1	175	55,040
1899....	297	12,725	17	1,840	5,575	102	4,175	43	2,460	1,876	1,108,735	7	2,225	141,560

(*a*) From the *New South Wales Statistical Register*. (*b*) Values including those of manufactures for which no quantity is stated, as follows: In 1895, $17,735; 1896, $17,970; 1897, $9,125; 1898, $14,445; 1899, $13,150. (*c*) Not stated in the reports. (*d*) Probably bismuth metal. (*e*) There was also exported from N. S. W. in 1897, iron oxide: 246 metric tons, $2,830, and iron ore, 5 metric tons, $35.

MINERAL PRODUCTION OF NEW ZEALAND. (*a*) (*b*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony Ore.		Coal.		Coke.		Gold—Kg.		Manganese Ore.	
1895.....	55	$7,430	752,680	$2,053,810	293	$3,575	9,129	$5,810,820	213	$2,625
1896.....	21	2,250	805,537	2,143,240	107	1,315	8,202	5,207,140	66	1,025
1897.....	10	785	854,164	2,259,575	14		7,827	4,901,020	183	2,705
1898.....	*Nil.*		921,546	2,378,655	9		8,714	5,403,445	220	3,515
1899.....	*Nil.*		990,838	2,438,085	18	45	12,117	7,565,865	137	2,035

MINERAL PRODUCTION—*Continued.*

Year.	Mixed Ores. Unspecified.		Silver—Kg.	
1895.....	63	$4,400	2,644	$53,395
1896.....	38	6,675	2,933	52,945
1897.....	1,586	29,460	5,716	104,360
1898.....	1,857	23,960	9,140	165,535
1899.....	1,330	32,945	10,866	204,190

MINERAL IMPORTS. (*c*) (IN METRIC TONS; £1=$5.)

Coal.		Machinery.	Railway Materials.	Tools and Implements.
109,929	$488 105	$770,045	$234,940	$299,325
103,384	470,690	1,417,200	163,270	350,690
112,681	490.695	2,005.265	682.855	450.905
117,274	526,115	2,349,315	499,985	555,755
101,259	464,075	2,267,075	636.820	465,100

(*a*) From *New Zealand Mines Statements*, by the Hon. A. J. Cadman, Minister of Mines, Wellington. (*b*) The exports are stated to be identical with the production, except in the case of coal, of which substance the exports were as follows: In 1895, 87,363 tons, value $416,710; in 1896, 80,796 tons, value, $359,920; in 1897, 77,280 tons, value, $347,975; in 1898, 57,333 tons, value, $251,905; in 1899, 90,912 tons, value, $415,425. (*c*) From *British Statistical Abstracts*.

MINERAL PRODUCTION OF QUEENSLAND. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony Ore.		Bismuth Ore.		Coal.		Copper Ore.		Gems.	Gold—Kg.		Lead.		Manganese Ore.	
1895.....	(*c*)		60	$16,290	328,237	$662,650	441	$65,485	*b*29,575	19,647	$11,054,435	369	$18,170	361	$5,515
1896.....	(*c*)		(*c*)		377,332	774,935	589	105,210	(*c*)	19,917	11,206,737	628	30,900	305	4,500
1897.....	(*c*)		1	670	364,142	699,445	293	63,225	(*c*)	25,129	12,765,705	391	20,585	403	7,530
1898.....	(*c*)		8	3,500	414,461	752,465	62	10,830	(*c*)	28,616	13,751,745	252	12,400	68	1,255
1899.....	41	$1,000	2	2,470	501,913	878,575	164	47,490	(*c*)	29,451	14,190,595	57	3,650	747	14,155

Year.	Opal.	Silver Ore.		Silver—Kg.		Stone. Building. (*b*)		Tin Ore.		Tungsten Ore	
1895.....	$163,750	7	$10,060	6,999	$150,210	52,206	$53,305	2,148	$340,665	25	$2,710
1896.....	116,500	(*c*)		8,687	160,810	(*c*)		1,579	245,090	3	300
1897.....	51,250	(*c*)		7,280	125,590	(*c*)		1,222	187,545	13	975
1898.....	33,225	(*c*)		3,235	52,925	(*c*)		1,041	182,510	79	12,700
1899.....	45,000	(*c*)		4,521	78,355	(*c*)		1,322	386,510	263	50,300

MINERAL IMPORTS OF QUEENSLAND. (*d*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Cement and Plaster of Paris—*Barrels.*		Coal.		Coke.		Glass and Glassware.	Gold Bullion—Kg.	
1895.....	47,244	$116,620	18,023	$91,575	(*c*)		$147,615	56·3	$33,375
1896.....	68,607	163,860	18,743	88,225	5	$20	176,330	189·2	108,405
1897.....	65,230	159,375	21,624	98,370	81	505	103,060	176·9	91,490
1898.....	56,441	143,425	23,281	99,125	199	1,290	217,015	198·0	115,625
1899.....	86,986	233,735	33,863	135,825	*Nil.*		164,395	306·4	172,260

Year.	Gold Specie.	Iron and Steel.		Petroleum—*Gallons.*		Silver Bullion. Kg.		Silver Specie.
		Rails, Track Material.	All other.					
1895.....	$3,001,000	$139,980	$1,468,785	1,638,975	$282,530	7·1	$210	$1,750
1896.....	400,000	138,230	1,519,595	1,271,910	265,645	5·0	120	13,380
1897.....	59,350	121,950	1,586,605	1,369,178	278,070	11·1	265	113,145
1898.....	1,330,500	440,520	1,761,220	1,928,311	329,955	26·8	375	54,840
1899.....	818,000	385,360	2,660,860	1,867,755	357,485	8·6	175	152,655

MINERAL EXPORTS OF QUEENSLAND. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony Ore.		Bismuth Ore.		Copper.								Gold—Kg.		Gold Ore.	
					Ore.		Ingot.		Matte.		Regulus.					
1895....	44	$1,935	44	$24,760	102	$10,840	315	$62,695	225	$31,200	211	$51,885	21,529	$11,360,545	199	$9,955
1896....	(*c*)		0·7	750	209	21,590	377	71,045	142	12,400	237	56,970	19,496	10,571,285	68	5,390
1897....	25	2,500	39	20,150	241	15,425	196	34,515	150	21,925	143	35,075	25,293	12,843,510	220	19,235
1898....	9	300	6	1,710	375	28,845	(*c*)		5	1,325	2	1,980	29,390	14,278,905	748	75,790
1899....	15	2,110	2	1,755	737	54,620	4	1,070	104	22,405	137	34,660	31,656	14,574,950	513	47,455

Year.	Precious Stones	Pyrites.		Silver.								Tin Ore.		Tin.		Tungsten Ore.	
				Ore.		Silver-Lead Bullion.		Precipitate.		Doré Bullion.—Kg.							
1895....	$29,575	(*c*)		77	$10,060	561	$198,710	1	$6,785	489	$26,340	1,180	$224,175	459	$146,760	34	$2,985
1896....	11,730	5	$770	181	46,350	174	103,630	0·8	1,500	3,163	144,460	751	136,410	355	97,485	23	2,365
1897....	5,700	(*c*)		259	35,080	301	37,350	(*c*)		1,823	210,565	636	115,750	161	675	(*c*)	
1898....	7,735	(*c*)		207	39,370	(*c*)		(*c*)		1,951	206,065	535	103,455	150	55,900	2	120
1899....	11,950	(*c*)		332	54,686	4	875	(*c*)		1,930	173,945	709	221,615	358	198,180	371	131,090

(*a*) From *Annual Reports of the Under Secretary of Mines*, Queensland, when not otherwise stated. (*b*) From *Mineral Statistics of the United Kingdom.* (*c*) Not reported. (*d*) From *Statistical Abstracts for the Several Colonial and other Possessions of the United Kingdom.*

MINERAL IMPORTS OF SOUTH AUSTRALIA. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Coal.		Coke.		Gold and Silver Bullion and Specie.	Iron.				Silver-Lead.			
						Bar, Sheet, Hoop, and Rod.		Galvanized, Plain, and Corrugated.		Metal.		Ore.	
1895....	261,117	$675,450	91,293	$531,875	$978,140	5,158	$163,205	4,153	$286,970	25,079	$4,293,305	134,878	$1,989,950
1896....	343,583	895,480	68,454	315,600	1,782,730	7,656	263,610	7,110	527,475	25,806	4,379,645	234,297	4,143,515
1897....	378,495	1,012,140	75,205	402,620	78,340	6,505	229,970	6,438	454,750	17,466	2,989,810	301,990	5,221,195
1898....	420,001	1,121,795	82,796	428,705	47,685	10,076	287,500	6,627	501,245	3,456	621,885	415,861	6,355,645
1899....	444,539	1,223,595	54,166	313,145	963,920	6,023	216,605	6,363	523,475	208	59,750	480,104	8,331,495

(*a*) From *British Statistical Abstracts*, except the figures for 1896, which are from the *Statistical Register of South Australia.*

MINERAL EXPORTS OF SOUTH AUSTRALIA. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Coal.		Copper.		Copper Ore.		Gold Bullion—Kg.		Lead.		Lead. Argentiferous.	
1895.....	876	$1,725	5,251	$1,132,470	268	$10,085	1,152·5	$643,960	20,766	$961,220	25,134	$3,026,310
1896.....	37,423	110,480	*b*4,689	1,097,320	354	15,750	265·1	157,905	24,353	1,183,620	13,869	1,416,555
1897.....	39,480	121,210	4,784	1,192,835	554	23,200	556·5	345,670	21,283	1,099,020	16,474	2,548,515
1898.....	39,399	124,680	*b*4,857	1,227,020	545	19,960	593·2	373,450	22,250	1,298,650	27,107	2,944,635
1899.....	47,568	154,440	*b*5,597	2,034,250	3,356	150,100	501·5	315,955	35,639	2,302,630	21,293	2,832,335

Year.	Lead Ore. Argentiferous.		Manganese Ore.		Matte.		Mica.	Salt.		Slate, Roofing.
1895.....	44,839	$1,132,015	49	$730	(*c*)		(*c*)	(*c*)		(*c*)
1896.....	129,438	3,652,360	(*c*)		3,385	465,910	$1,660	*d*19,332	$127,280	$4,925
1897.....	180,870	5,394,000	(*c*)		2,324	342,235	5,690	*d*29,374	174,805	18,865
1898.....	139,567	4,779,410	5	50	867	128,300	500	31,471	192,725	3,510
1899.....	188,916	5,869,280	102	590	1,293	174,110	(*c*)	35,623	220,570	5,280

Year.	Tin Ore.		Zinc.		Various Ores.	
1895.....	70	$9,075	26	$1,610	6	$360
1896.....	(*e*)		36	2,020	2	90
1897.....	(*e*)		11	590	52	2,095
1898.....	5	25	18	1,290	30,931	516,765
1899.....	1	75	27	2,215	844	38,010

(*a*) From the *Mineral Statistics of the United Kingdom*, except the figures for 1896, which are from the *Statistical Register of South Australia*, Part IV. and those for 1897, which are from *British Statistical Abstracts*. (*b*) Includes yellow metal. (*c*) Not reported. (*d*) Exported in 1896 also rock salt, 3 metric tons ($50). In 1897, 2 metric tons ($30). (*e*) No tin ore exported in 1896; but tin, block and sheet, 5 metric tons ($1,795). In 1897, 2 metric tons ($825).

MINERAL PRODUCTION OF TASMANIA. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Coal.		Copper Ore.		Gold—Kg.		Iron Ore.		Lead-Silver Ore.		Stone.				
											Bluestone.			Limestone.	
											Cubic Yards	*Tons.*	Total Value.	*Tons*	Total Value.
1895	33,703	$70,145	34	$2,600	1,709	$1,061,645	(*b*)		18,194	$879,785	7,144	7,961	$13,540	1,419	$7,500
1896	44,286	86,770	52	7,450	1,947	1,187,870	203	$250	21,150	1,114,740	4,256	(*b*)	3,435	2,621	3,101
1897	43,210	84,640	113,261	1,618,250	2,399	1,446,205	999	370	17,806	986,125	(*b*)	(*b*)		1,702	6,200
1898	49,902	97,271	(*d*)		2,309	1,407,425	1296	1,910	196,707	3,281,065	(*b*)	(*b*)		45,324	53,195
1899	43,803	85,040	*e*60,985	2,792,860	2,612	1,637,725	(*b*)		118,721	1,397,395	(*b*)	(*b*)		71,747	202,699

Year.	Stone.—*Continued.*						Tin Ore.					
	Freestone, Flagstones and Building Stones.			Rubble or Metal.			Quantity.			Value.		
	Cubic Feet.	*Loads*	Total Value.	*Cubic Feet.*	*Tons.*	Total Value.	Alluvial.	Lode.	Total.	Alluvial.	Lode.	Total.
1895....	21,470	(*b*)	$6,170	1,140	6,200	$5,175	3,887	39	3,926	$726,230	$180	$766,410
1896....	13,575	4,220	7,590	*c* 4,556	(*b*)	1,635	3,867	(*b*)	3,867	804,395	(*b*)	804,395
1897....	82,197	(*b*)	5,805	95,202	13,274	11,010	3,281	1	3,282	545,545	85	545,630
1898....	19,560	(*b*)	4,025	525,258	70,701	89,235	2,882	(*b*)	2,882	578,810	(*b*)	578,810
1899....	14,400	(*b*)	3,079	88,425	12,060	13,151	3,333	(*b*)	3,333	1,354,320	(*b*)	1,354,320

(*a*) From *Statistics of the Colony of Tasmania*, Part V., Production. There was also mined in 1898, 6 tons of nickel ore, valued at $2,000. (*b*) Not reported. (*c*) Represents cart-loads. (*d*) Included with silver-lead ore. (*e*) In addition there were produced 8,496 tons of copper bullion valued at $3,349,800.

MINERAL IMPORTS OF TASMANIA. (*a*) (IN METRIC TONS AND DOLLARS; £1=$5.)

Year.	Cement and Whiting.		Coal and Coke.		Copper and Lead.	Glass, Sheet, Crown, and Plate.	Glassware Including Earthenware.	Gold Specie.	Iron. Railway Material	Iron and Tin Plate.	Jewelry and Plate.	Silver Specie and Bullion.
1895....	1,605	$14,855	36,139	$58,615	$5,590	$8,125	$36,140	$485,000	$58,465	$151,120	$11,960	$15,065
1896....	897	8,775	28,145	11,838	5,105	10,525	69,010	(*b*)	148,960	179,335	22,250	11,100
1897....	1,607	16,895	41,436	105,475	4,950	15,795	84,845	250,000	89,190	254,500	44,740	3,135
1898....	2,465	31,985	47,371	115,271	10,740	18,072	78,020	10,045	239.617	280,862	50,175	58,580
1899....	1,708	21,342	75,708	212,665	10,173	17,035	109,225	96,000	218,504	353,454	54,704	48,115

(*a*) From *Statistics of the Colony of Tasmania.* (*b*) Not reported.

MINERAL EXPORTS OF TASMANIA. (*a*) (IN METRIC TONS AND DOLLARS; £1=$5.)

Year.	Bismuth Ore.		Coal and Coke.		Copper Ore.		Copper. Blister.		Glassware Including Earthenware.	Gold.				
										Ore.		Bullion—Kg.		Coin.
1895....	(*b*)		101	$705	205	$48,385	(*b*)		$40	395·0	$28,890	1,664	$1,062,650	$58,950
1896....	1·0	$400	380	680	86	8,295	(*b*)		545	1,032·0	42,835	1,759	1,118,065	(*b*)
1897....	(*b*)		2,271	3,095	53	4,560	4,585	$1,825,585	360	421·6	19,970	1,829	1,131,440	(*b*)
1898....	4	550	2,605	3,269	467	30,660	5,092	1,861,165	(*b*)	1,074·9	18,065	1,521	924,325	325,000
1899....	6	4,500	2,740	6,005	1,755	119,125	8,476	3,690,275	(*b*)	547·6	23,505	1,647	1,006,175	(*b*)

Year.	Iron.				Iron Oxide.		Lead.		Silver.				Tin.	
	Old Metal.		Rails.						Ore.		Bullion.		Ore.	
1895....	96	$670	117	$1,395	66	$325	7·0	$380	20,575	$1,139,580	(*b*)		13	$1,465
1896....	300	2,710	61	900	29	145	2·5	100	21,150	1,114,740	(*b*)		2	10
1897....	198	1,450	57	50	(*b*)		19·3	725	19,828	1,084,465	(*b*)		5	2,960
1898....	117	1,295	(*b*)		20	110	(*b*)		14,163	838,090	(*b*)		6	835
1899....	96	745	(*b*)		6	30	5	290	18,618	812,090	1,453	$232,255	58	18,120

Year.	Tin.—*Continued.*		Zinc.	
	Metal.			
1895....	2,771	$837,305	9	$500
1896....	2,743	795,180	10	380
1897....	2,462	749,970	42	1,890
1898....	2,006	705,810	6	265
1899....	2,273	1,391,615	8	680

(*a*) From *Statistics of the Colony of Tasmania.* Additional exports in 1897: Jewelry and plate, $6,105; silver coin, $12,875; unclassified ore, 30 metric tons, $1,450; mineral sand, ½ metric ton, $5; copper metal, 1½ tons, $40; iron ore, 904 tons, $4,015; manganese ore, 2 tons, $30; mineral oxide, 5 tons, $45; in 1898: Jewelry and plate, $3.395; iron ore, 1,735 tons, $8,540; in 1899: Asbestic, 203 tons, $1,815; tin plates, $2,150; iron ore, 3,635 tons, $17,350. (*b*) Not stated in the report .

MINERAL PRODUCTION OF VICTORIA. (*a*) (IN METRIC TONS AND DOLLARS; £1=$5.)

Year.	Antimony Ore.		Coal.		Lignite.		Copper Ore		Gold—Kg. (*b*)		Lead Ore. Argentif.		Slate and Flagging.		Tin Ore.	
1895..	(*d*)		197,334	$592,000	1,988	$5,239	7	$1,050	23,019	$14,801,720	20	$500	366	$450	76	$15,662
1896..	(*d*)		230.187	565,060	5,908	10,705	(*d*)		25,041	16,101,740	(*d*)		386	485	47	8,995
1897..	5	$100	240,057	543,200	4,894	6,885	(*d*)		25,280	16,255,320	(*d*)		(*d*)	*e*125,000	48	8,250
1898..	118	2,550	246,845	515,495	2,915	3,835	(*d*)		26.041	16.745,140	20	1,200	(*d*)	100,000	87	19,565
1899..	(*d*)		266,578	567,610	(*d*)		(*d*)		26,578	17.090,000	(*d*)		(*d*)		158	56,000

MINERAL IMPORTS OF VICTORIA. (*c*)

Year.	Coal.		Iron and Steel.	
1895..	553,343	$1,005,235	42,788	$1,422,400
1896..	511,020	970,175	45.126	1,996,845
1897..	535,812	1,143,235	56,832	2,294,645
1898..	571,326	1,288,440		2,674,705
1899..	532,676	1,380,685		3,507,105

MINERAL EXPORTS OF VICTORIA. (*c*)

Year.	Coal.		Coke and Charcoal.		Gold.		Silver. (Specie)
					Bullion.	Specie.	
1895..	161	$600	210	$2,060	$612,505	$18,141,180	$41.860
1896..	319	1,770	295	3,050	323,025	16,171,535	53,185
1897..	283	1,980	1,212	15,690	969,055	31,392,535	11,605
1898..	411	1,775	567	7,033	1,355,240	28,253,635	122,300
1899..	445	1,695	430	8.310	988,210	20,821,110	144,500

(*a*) From Annual Reports of the Secretary for Mines of the Colony; additional products in 1897: Bricks, estimated value, $11,250; pottery, estimated value, $8,900; in 1898: Brick, $12,500; pottery, $10,000; infusorial earth, 142 tons, $1,400; in 1899: Infusorial earth, $1,250; brick, $15,000; pottery, $12,500; building brick, $100,000. (*b*) The values are not separately stated in the report, and are estimated at $20 per oz.=$643·02 per kg. (*c*) From *British Statistical Abstracts.* (*d*) Not stated in the reports. (*e*) Represents estimated value of building stones (basalt, sandstone, granite, slate, flagging, etc.).

MINERAL IMPORTS OF WESTERN AUSTRALIA. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Brassware.	Cement. *No. of Barrels.*		Clay. Bricks.	Clay. Earthen and Chinaware.	Clay. Tiles.	Coal.		Coke and Patent Fuel. *No. of Sacks.*		Copper. Ingot.
1895.....	$9,220	15,048	$30,290	$6,305	$68,220	$2,815	39,125	$147,395	368	$510	(*c*)
1896.....	18,980	(*c*)	70,845	19,340	87,485	7,585	71,680	197,515	(*c*)	2,485	$8,375
1897.....	23,935	47,457	81,305	12,120	101,320	16,365	139,369	474,690	(*c*)	10,825	1,695
1898.....	22,835	52,077	96,890	14,350	66,305	10,030	134,315	421,230	7,936	5,340	2,110
1899.....	12,320	40,741	90,320	8,945	62,445	4,640	129,512	475,720	*d* 1,456	9,840	2,805

Year.	Copper.—*Continued.* Rod, Sheet, and Wire.	Copper Sulphate.	Glass and Glassware	Gold Coin.	Gold and Silver Leaf.	Iron. Pig.		Iron. Galvanized. (Corrugated Sheet.)		Iron. Other Manufactures.
1895.....	$4,335	$455	$64,410	$4,540,000	$2,765	289	$3,870	3,848	$289,935	$230,670
1896.....	9,440	735	103,210	4,751,850	2,565	639	12,455	7,467	525,050	771,945
1897.....	12,295	625	137,815	225,000	2,505	953	14,095	11,689	897,035	661,630
1898.....	18,695	885	86,740	675,000	4,265	1,431	20,620	8,997	685,575	631,145
1899.....	15,515	(*c*)	105,890	25,000	1,905	1,379	25,345	4,280	341,770	649,735

Year.	Iron and Steel Wire.	Steel.	Lead—Sheet, Pig and Pipe.		Paraffine Wax.	Petroleum and Turpentine. *No. of Gallons.*		Plaster of Paris.		Quicksilver. *No. of Flasks.*	
1895.....	$53,995	$21,765	96	$6,040	$2,640	495,024	$82,730	52	$1,050	323	$9,880
1896.....	67,715	82,935	321	20,250	3,780	853,649	159,765	245	3,545	840	20,235
1897.....	82,545	80,340	537	37,115	3,750	1,058,022	163,735	496	6,225	623	22,705
1898.....	97,580	64,195	469	27,240	8,510	1,165,375	195,635	246	2,725	691	25,280
1899.....	83,735	1,007,825	146	8,425	9,095	1,241,159	191,180	62	970	(*c*)	37,900

Year.	Salt. Rock. *No of Sacks*		Salt. Other Kinds.		Silver Coin.	Sodium Salts. Carbonate. (Crystals.)		Sodium Salts. Hydrate.	Sodium Salts. Other Salts inc. Potash.	Stone. Grindstones. *Number.*		Stone. Marble and other kinds
1895.....	212	$595	833	$9,710	$92,000	(*c*)	$1,270	$2,460	$1,240	*b* 700	$660	$7,140
1896.....	(*c*)	260	997	10,690	147,095	(*c*)	2,150	2,420	4,940	(*c*)	2,055	22,070
1897.....	(*c*)	410	1,211	11,568	103,000	143	2,730	3,955	4,940	(*c*)	2,445	20,190
1898.....	332	275	1,346	12,665	1,050	137	2,390	5,510	6,505	1,206	1,140	19,190
1899.....	(*c*)	205	1,567	14,290	5	(*c*)		(*c*)	(*c*)	(*c*)	1,085	13,250

Year.	Sulphur. *No. of Casks.*		Tin. Ingot.	Tin. Block, Foil, Plate, and Wares.	Whiting.	Zinc, Sheet and Ingot.
1895.....	344	$1,230	(*c*)	$15,900	$1,065	$3,970
1896.....	(*c*)	720	$4,090	34,395	1,950	6,295
1897.....	(*c*)	600	6,360	24,835	1,530	7,565
1898.....	283	970	6,490	19,150	1,625	7,710
1899.....	(*c*)	1,295	13,235	*e* 4,900	1,530	16,530

(*a*) From the *Blue Books for Western Australia*, except the figures for 1896, which are from the *Annual Report of the Collector of Customs*, wherein only the values of the imports are stated. (*b*) Number of packages. (*c*) Not stated in the reports. (*d*) Metric tons. (*e*) Foil and plate only.

MINERAL EXPORTS OF WESTERN AUSTRALIA. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Coal.		Copper Ore.		Gold. Bullion—Kg.	Gold. Coin.	Iron and Steel.	Lead Ore.		Mica.	Tin Ore.		
1895.....	15,095	$92,675	839	$64,760	7,201	$4,398,740	$460		(*b*)		$15	281	$48,515
1896.....	(*b*)	75,205	(*b*)	500	8,748	5,344,040	(*b*)	$130	(*b*)		(*b*)	(*b*)	21,690
1897.....	23,756	129,010	86	5,165	20,994	12,824,885	3,130,400	4,165	(*b*)	$20	1,045	96	16,375
1898.....	26,240	149,135	361	21,330	32,633	19,953,490	75,000	41,090	5	165	(*b*)	69	13,800
1899.....	45,283	226,415	2,023	207,260	44,587	27,256,840	398,460	88,790	16	480	250	313	115,815

(*a*) From the *Blue Books for Western Australia*, except the figures for 1896, which are from the *Annual Report of the Collector of Customs*, Perth. In 1896 there were also exported brassware, $320; silver plate, $85; and salt, $80. (*b*) Not stated in the reports.

AUSTRIA-HUNGARY.

THE latest official statistics of the mineral production, imports, and exports of Austria-Hungary are summarized in the following tables:

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND CROWNS.)
(1 crown = 20·3 cents.)

Year.	Alum.		Alum and Pyritous Shale.		Antimony.		Antimony Ore.		Asphaltic Rock.		Bismuth Ore.		Coal.	
1895	885	109,870	5,716	19,910	296	184,062	695	111,200	404	16,236	185		9,722,679	68,208,814
1896	919	113,110	25,184	40,172	422	261.064	905	161,260	390	22,684	*Nil.*		9,899,522	70,409,850
1897	851	110,822	21,585	35,890	425	226,460	864	146,898	300	17,736	1		10,492,771	76,809,728
1898	1,037	145,632	28,914	42,734	343	208,470	679	114,334	643	31,208	*Nil.*		10,947,522	109,475,219
1899	604	83,566	19,879	33,555	271	168,462	410	76,218	2,635	75,671	0·3	1,898	11,455,139	114,551,387

Year.	Coal, Lignite.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.		Gold—Kg.		Gold Ore.	
1895	18,389,147	69,847,056	865	921,980	160	7,186	7,435	573,794	246	98,462	75·0	233,506	104	77,994
1896	18,882,537	72,455,216	1,001	1,105,808	170	8,344	6,823	546,538	265	105,114	69·8	197,826	416	96,824
1897	20,458,093	80,168,846	1,083	1,229,368	125	6,270	7,405	558,786	276	116,020	67·6	187,352	647	65,876
1898	21,083,361	86,985,582	1,041	1,255,620	360	22,630	6,791	506,496	209	94,328	71·5	204,002	448	109,752
1899	21,751,794	95,167,467	1,123	1,842,084	475	19,535	6,731	483,055	235	101,473	75·7	188,728	387	62,038

Year.	Graphite.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.		Litharge.	
1895	28,443	1,971,542	1,384,911	5,942,768	660,549	45,716,474	8,085	2,409,960	12,919	1,766,488	2,034	595,416
1896	35,972	2,432,916	1,448,615	6,892,958	693,188	47,474,500	9,769	3,054,432	14,563	2,117,128	1,738	543,006
1897	38,504	2,705,292	1,613,876	7,532,096	762,685	53,252,476	9,680	3,152,420	14,145	2,323,798	1,626	531,338
1898	33,062	1,747,132	1,733,649	8,455,376	837,767	59,026,726	10,340	3,579,024	14,363	2,460,782	1,520	561,400
1899	31,819	1,976,402	1,725,143	9,841,306	872,352	66,712,942	9,736	3,744,389	12,820	2,548,660	1,526	585,662

Year.	Manganese Ore.		Mineral Paint.		Nickel and Cobalt Products(*b*)		Petroleum.		Quicksilver		Quicksilver Ore		Salt.	
1895	4,352	83,200	3,164	147,264	*Nil.*		188,634	8,928,706	535	2,337,024	86,683	1,594,436	278,875	47,803,564
1896	3,950	68,564	3,979	167,520	*Nil.*		262,356	10,377,710	564	2,299,390	83,305	1,556,910	308,933	45,970,706
1897	6,012	95,922	3,653	168,098	37·6	50,110	275,204	11,753,384	532	2,380,242	88,238	1,628,118	331,084	51,122,882
1898	6,132	95,590	3,213	148,784	58·8	54,046	323,142	16,423,882	491	2,297,074	88,519	1,602,152	341,959	53,038,994
1899	5,411	91,193	2,055	122,835	38·1	42,859			536	2,460,105	92,323	1,774,728	342,059	50,623,802

Year.	Silver—Kg.		Silver Ore.		Sulphuric Acid.		Sulphur, Crude Rock		Tin.		Tin Ore		Tungsten Ore.	
1895	40,081	5,049,966	18,113	4,588,086	7,431	408,970	830	16,586	60	101,076	24	5,116	35	18,308
1896	39,904	4,281,826	18,701	3,843,066	7,972	442,364	643	16,542	54	91,300	15	4,946	22	13,960
1897	40,026	3,904,826	20,628	3,743,602	8,515	402,108	530	9,674	48	84,028	16	4,844	31	38,496
1898	40,304	3,770,108	20,886	3,525,190	7,003	318,846	496	8,306	48	94,144	13	3,792	36	66,164
1899	39,564	3,809,889	21,554	3,714,608	7,814	315,226	555	7,628	41	123,193	54	5,255	50	111,297

Year.	Uranium Ore.		Uranium Salts.		Zinc.		Zinc Ore.	
1895.....	31	103,522	4·5	128,018	6,456	2,192,016	25,862	768,660
1896.....	30	56,870	4·2	94.118	6,888	2,570.782	26,887	948,066
1897.....	44	90,022	4·4	85.044	6,236	2,433,218	27,463	1,060,282
1898.....	51	103,438	4·3	79,156	7,302	3,517,988	27,395	1,598,580
1899.....	49	107,104	7·6	136,566	7,192	4,041,270	37,100	2,713,942

(*a*) From *Statistisches Jahrbuch des K. K. Ackerbau Ministeriums; Der Bergwerksbetrieb Oesterreiche.* Iron, common, cast, second fusion. (*b*) In 1897 and 1898 the figures represent nickel speiss, nickel sulphate and cobalt sludge.

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 crown = 20·3 cents.)

Year.	Alum Ore.		Antimony.				Asphaltum.		Carbon Oxysulphide.		Coal.	
			Ore. (*b*)		Crude and Regulus.						Briquettes.	
1895.....	634	$462	1,240	$26,877	465	$57,507	2,285	$46,517	237	$17,117	29,421	$95,134
1896.....	*d* 20	97	1,361	22,572	500	59,313	2,740	57,619	352	25,659	31,179	100,212
1897.....	*d* 60	243	1,800	34,563	523	63.360	3,057	65,001	432	7,132	27,022	87,605
1898.....	*Nil.*		2,201	20,219	855	109,681	3,125	66,422	771	56,393	31,781	102,840
1899.....	*Nil.*		1,965	34,205	940	139,502	3,060	65,467	1,120	81,896	31,137	101,338

Year	Coal—*Continued.*				Coke.		Copper.		Copperas.		Copper Sulphate.	
	Coal.		Lignite.									
1895.....	1,068,046	$2,285,536	3,517,901	$4,544,071	12,033	$4,580	286	$58,438	521	$845	(*c*)	
1896.....	1,132,625	2,368,715	3,761,728	5,094,630	25,550	58,914	159	31,305	595	964	3·0	$288
1897.....	1,118,024	1,819,409	3,870,530	4,118,139	(*c*)		213	46,091	592	1.199	6·5	625
1898.....	1,239,498	2,667,095	4,516,581	5,693,094	(*c*)		153	30,917	745	1,807	*Nil.*	
1899.....	1,238,855	2,640,015	4,292,584	5,948,062	10,036	38,814	165	48,537	771	2,497	*Nil.*	

Year.	Gold—Kg.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.	
1895.....	3,187·27	$1,973,307	955,262	$963,366	322,206	$4,782,332	2,277	$130,950	80	$5,511
1896.....	3,208·04	2,131,866	1,269,680	1,225,084	383,698	5,649,301	1,911	107,711	405	17,099
1897.....	3,068·00	2,038,224	1,421,130	1,530,967	402,503	5,866,552	2,527	149,302	525	21,435
1898.....	2,768·00	1,842,651	1,666,837	1,838,124	448,621	6,899,138	2,305	137,817	771	22,026
1899.....	3,069·00	2,042,159	1,567,860	1,999,002	451,647	6,929,527	2,166	150,402	526	20,036

Year.	Litharge.		Manganese Ore.		Mineral Paints.		Nickel and Cobalt.				Petroleum.		Pyrites.	
							Ore.		Products.					
1895.....	615	$48,459	3,525	$1,206	371	$4,543	55	$8,583	18	$2,200	2,083	$28,486	69,195	$113,456
1896.....	465	31,239	2,101	1,591	334	2,435	46	1,829	18	2,971	2,168	21,885	52,697	91,730
1897.....	155	13,888	4,030	4,710	460	2,986	32	1,269	7·9	957	2,299	22,939	44,454	71,500
1898.....	188	15,854	8,087	3.776	247	893	*Nil.*		*Nil.*		2,471	24,746	58,079	93,522
1899.....	213	18,351	5,073	5,765	394	507	*Nil.*		*Nil.*		2,125	21,822	79,519	129,879

Year.	Quicksilver—Kg.		Salt.		Silver—Kg.		Sulphur.		Sulphuric Acid.		Zinc Ore.	
1895.....	1,129	$972	169,395	$5,450,345	20,432·3	$499,038	102	$3,171	4,223	$37,076	(*c*)	
1896.....	1,100	906	180,133	6,191,861	19,916·0	477,677	138	3,781	3,550	26.441	(*c*)	$338
1897.....	700	374	171,711	5,375,788	26,790·0	622,634	112	3,317	3,397	26,258	30	*Nil.*
1898	6,800	5,562	178,551	5,679.534	18.799·0	448,427	93	2,883	1,318	13,906	30	3,634
1899.....	27,000	22,025	182,593	5,479,782	21,018·0	492,803	116	3,654	1,463	3,573	1,197	5,623

(*a*) From *Magyar Statisztikai Evkönyv.* (*b*) This does not include the ore consumed in smelting the product of antimony. (*c*) Not stated in the report. (*d*) Represents refined alum.

MINERAL IMPORTS OF AUSTRIA-HUNGARY. (a) (IN METRIC TONS AND DOLLARS.)

(1 crown = 20·3 cents.)

Year.	Alum.		Aluminum and Alloys.		Aluminum Sulphate and Chloride.		Ammoniacal Liquor.		Ammonium. Chloride and Sulphate.		Ammonium. Hydrate.		Antimony. Ore.		Antimony. Regulus. Kg.	
1895.....	338	$12,186	48	$37,332	1,278	$25,560	877	$5,260	305	$40,319	103	$5,377	15	$1,260	2,100	$311
1896.....	359	12,942	50	37,916	1,128	22,554	507	3,042	323	46,746	71	3,697	15	1,302	700	92
1897.....	346	12,463	67	50,096	1,351	27,039	565	2,710	339	42,430	128	6,677	8	672	600	78
1898.....	334	12,013	101	62,143	1,822	29,146	230	1,105	430	42,388	80	4,150	12	1,033	28,200	4,004
1899.....	332	11,938	120	58,015	1,299	20,789	72	363	358	37,957	46	2,587	10	840	30,400	5,107

Year.	Arsenic, Arsenious Acid, and Sulphide.		Asbestos. Crude.		Asbestos. Manufactures.		Asphalt. Crude Rock.		Asphalt. Mastic and Bitumen.		Barytes (Including M'f'd Product).	
1895.....	292	$26,948	432	$22,620	108	$44,070	2,410	$17,949	872	$20,930	5,098	$53,826
1896.....	309	30,527	185	11,810	165	67,046	4,715	31,181	1,621	35,658	5,377	56,850
1897.....	259	24,021	625	33,041	134	48,774	5,824	38,894	1,309	28,805	4,947	52,123
1898.....	287	34,080	609	33,316	138	54,200	5,973	40,621	1,117	24,574	5,012	52,776
1899.....	284	32,390	865	44,698	135	55,146	7,301	69,471	1,546	28,594	5,443	45,608

Year.	Borax. Crude, and Boric Acid.		Borax. Refined.		Brass, German Silver and Tombac. Crude, Old, and Remnants.		Brass, German Silver and Tombac. Bars, Sheets, Wire, etc.		Brass, German Silver and Tombac. Wares.		Cement.	
1895.....	1,908	$113,153	62	$5,695	2,742	$466,771	131	$25,370	510	$612,500	32,012	$205,765
1896.....	1,363	83,222	76	7,038	3,118	538,065	113	23,359	526	631,440	35,290	226,496
1897.....	1,206	68,772	63	5,135	2,660	489,052	152	50,639	549	658,920	32,479	208,756
1898.....	784	44,871	185	14,832	3,232	630,147	182	51,577	607	765,324	30,745	197,479
1899.....	2,212	125,507	130	10,432	2,699	651,771	168	61,012	588	764,010	21,524	129,694

Year.	Chloride of Lime.		Chrome Ore.		Clay Products. Kaolin and Feldspar.		Clay Products. Manufactures.		Clay Products. Potters' and Other Clays.		Coal.	
1895.....	2,538	$75,446	1,827	$37,962	6,532	$76,353	194,476	$1,135,200	27,493	$99,702	4,503,003	11,116,194
1896.....	1,989	63,635	1,891	41,602	7,425	82,661	213,208	1,285,200	30,072	108,258	5,174,321	12,556,256
1897.....	1,820	58,256	1,109	22,188	6,913	75,376	186,297	1,233,200	28,925	104 655	5,121,475	10,552,887
1898.....	2,851	85,542	2,206	39,701	7,991	88,160	183,822	1,230,400	31,905	114,859	5,396,760	12,524,317
1899.....	3,749	113,045	1,874	35,990	8,152	94,016	177,119	1,110,000	30,799	110,876	5,29.,700	14,072,800

Year.	Coal, Lignite.		Coke.		Copper. Ore.		Copper. Crude and Old.		Copper. Bars, Sheets, Wire, etc.		Copper Sulphate.	
1895.....	16,797	$36,281	533,402	$2,242,115	31	$1,488	11,747	$2,768,864	98	$28,842	895	$68,043
1896.....	19,981	43,159	491,028	2,044,014	1	22	13,666	3,348,549	126	39,302	2,084	179,995
1897.....	19,609	43.088	533,463	2,279,648	81	4,588	15,926	3,981,080	94	30,981	6,822	577,990
1898.....	19,393	42,446	606,783	2,876,321	64	1,272	17,443	4,706,135	159	55,142	5,271	453,398
1899.....	20,879	46,850	564,005	2,652,153	*Nil.*		16,185	5,969,925	156	71,043	2,345	274,262

Year.	Copper and Iron Sulphates, Mixed.		Copperas.		Cryolite.		Fertilizers, Mineral.		Fluorspar.		Glass. Crude and Ground.		Glass. Remnants.	
1895.....	56	$2,023	871	$5,227	229	$48,194	89,286	$107,143	3,528	$24,735	236	$37,772	4,213	$29,491
1896.....	40	1,440	575	3,453	265	55,720	96,575	115,891	3,821	19.707	256	40,928	3.744	26,306
1897.....	153	5,512	401	2,408	211	44,194	75,834	91,001	4,201	41,344	270	43,152	4,651	32,558
1898.....	93	3,352	466	2,330	275	58,676	84,820	101,784	4,169	41,809	299	47,840	6,860	48,021
1899.....	28	994	408	1,920	342	73,822	81,205	64,964	4,958	41,947	341	54,600	8,574	60,017

Year.	Glass.—*Continued.* Manufactures.		Gold. Bullion—Kg.		Gold. Coin—Kg.		Gold. Old and Dross. Kg.		Graphite.	
1895.....	4,038	$790,400	5,223	$3,221,447	30,279	$17,128,043	4,761	$76,290	640	$10,426
1896.....	3,989	847,600	13,053	7,759,426	30,149	16,705,671	5,051	17,260	697	11,241
1897.....	3,782	874,800	33,668	20,130,770	32,752	17,895,693	5,572	23,120	948	15,322
1898.....	4,008	903,600	487	55,562	15,917	8,722,516	7,920	11,520	1,109	18,159
1899.....	4,081	873,400	719	425,887	13,850	7,549,419	9,401	10,802	815	13,491

Year.	Gypsum. Burned.		Gypsum. Crude.		Hydrochloric Acid.		Iron. Ore.		Iron. Pig and Old.		Iron. Manufactures.	
1895.....	10,916	$109,164	850	$3,740	467	$3,734	117,600	$538,291	175,400	$2,050,800	23,078	$3,990,400
1896.....	11,736	103,272	821	3,613	529	4,230	107,018	531,193	148,217	2,057,200	21,910	4,258,400
1897.....	12,101	106,487	980	4,312	721	5,765	134,778	719,365	164,433	2,390,800	28,876	4,582,400
1898.....	13,300	117,040	991	4,360	766	6,128	178,507	685 003	173,919	2,450,000	28,688	4,627,200
1899.....	13,441	107,351	1,336	5,878	350	2,834	212,412	872,189	126,371	2,575,200	23,220	4,434,400

Year.	Iron and Steel. Bars, Sheets, Wire, etc.		Lead. Alloys, Crude.		Lead. Bars.		Lead. Litharge.		Lead. Ore.		Lead. Red and Yellow.	
1895.....	30,909	$1,022,400	8,974	$466,643	208	$16,632	355	$25,596	416	$13,000	371	$29,704
1896.....	27,809	1,054,000	7,221	389,940	218	15,718	233	17,738	540	15,774	432	32,809
1897.....	18,625	698,000	5,887	336,714	148	11,240	224	16,128	441	14,124	543	41,108
1898.....	26,421	1,003,200	9,746	623,744	153	12,208	280	22,440	459	16,532	555	46,824
1899.....	12,367	604,600	8,836	636,199	235	20,645	224	18,000	465	20,447	465	39,102

Year.	Lead.—*Con.* White.		Magnesium Chloride.		Manganese Ore.		Millstones.		Mineral Paints.		Nickel. Crude and Old.	
1895.....	187	$18,562	1,353	$21,654	2,772	$99,332	1,229	$68,852	4,244	$58,072	168	$102,387
1896.....	156	13,894	1,333	21,288	7,371	105,618	1,205	67,474	4,362	58,376	161	100,920
1897	111	9,692	1,530	22,953	8,018	121,874	1,275	71,394	4,553	61,698	157	100,995
1898.....	115	10,589	2,196	31,442	5,396	69,070	1,429	80,018	4,979	68,912	137	88,776
1899.....	80	7,397	2,043	32,685	5,855	79,632	1,457	81,620	5,106	71,088	119	78,342

Year.	Nickel.—*Con.* Sheet, Wire, etc.		Nickel and Cobalt Ores.		Nitric Acid.		Oxide. (Potash.)		Ozokerite.		Peat and Peat Coke.	
1895.....	5	$5,696	1,020	$104,010	16	$896	285	$21,436	2·2	$255	1,993	$5,821
1896.....	5	5,344	719	76,193	21	1,159	987	65,945	2·0	240	2,002	5,847
1897.....	7	7,232	55	6,588	23	1,271	333	25,104	2·4	288	2,189	6,392
1898.....	9	9,172	510	65,267	22	1,260	300	19,720	2·5	350	1,511	4,412
1899.....	11	11,152	198	26,110	39	2,181	520	37,100	0·5	70	2,075	6,000

Year.	Petroleum. Crude.		Petroleum. Refined.		Phosphorus and Phosphoric Acid.		Potassium Salts. Chloride.		Potassium Salts. Chromate.		Pyrites.	
1895.....	120,479	$2,431,227	16,876	$566,460	206	$98,928	2,679	$80,355	29	$5,074	54,610	$262,126
1896.....	69,013	1,129,002	17,943	521,312	224	114,472	2,475	74,241	34	5,865	50,691	243,316
1897.	70,573	908,515	21,249	592,732	209	99,354	2,206	79,382	34	5,814	49,462	237,417
1898.....	58,580	725,788	22,299	684,381	209	97,984	2,258	81,281	3	403	52,282	209,128
1899.....	75,885	1,131,905	21,823	707,800	221	103,589	3,264	228,473	1	154	54,844	285,187

Year.	Quicksilver. Kg.		Salt.		Silica, Quartz and Sand.		Silver. Bullion—Kg.		Silver. Old and Dross—Kg.		Silver. Coin—Kg.	
1895.....	4,200	$3,326	40,396	$162,744	58,494	$164,490	49,370	$992,859	60	$696	4,400	$90,353
1896.....	1,300	967	53,680	214,947	59,150	179,932	138,420	2,887,956	550	860	5,730	137,244
1897.....	1,000	772	46,057	184,260	61,532	195,158	99,900	1,814,184	1,000	2,608	3,670	75,944
1898.....	6,300	5,090	41,870	167,520	70,296	219,200	15,400	274,131	3,000	1,680	5,470	103,424
1899.....	2,600	2,423	37,883	151,583	71,279	282,020	28,930	527,338	600	1,420	5,060	110,300

Year.	Slag and Slag Wool.		Slate, Roofing and Other.		Sodium Salts.							
					Bi-Sulphate.		Carbonate.		Carbonate. (Calcined.)		Hydrate.	
1895.....	981	$1,844	15,667	$372,800	137	$2,744	40	$479	551	$11,012	1,163	$45,200
1896.....	240	452	15,932	388,000	144	2,882	57	690	1,332	31,963	835	28,718
1897.....	4,717	8,868	16,758	406,030	91	1,826	45	1,088	2,787	66,883	1,450	49,518
1898.....	9,655	19,319	16,025	389,200	89	1,784	53	642	2,408	48,451	1,498	51,862
1899.....	5,665	11,330	15,562	379,550	85	1,692	62	748	1,123	23,591	1,669	57,521

Year.	Sodium Salts.—*Continued.*				Stone.							
	Nitrate.		Sulphate.		Lithographic Stone.		Marble.		Paving.		Not Elsewhere Specified.	
1895.....	43,059	$1,808,470	6,617	$52,940	684	$27,083	1,886	$22,637	5,459	$21,836	79,869	$329,043
1896.....	33,086	1,323,452	4,678	32,747	647	25,633	2,347	28,159	8,476	33,904	87,796	290,725
1897.....	39,600	1,584,016	2,879	20,158	524	20,739	2,333	27,995	16,961	67,843	118,848	368,860
1898.....	41,773	1,670,928	4,476	31,136	786	31,146	2,769	33,224	11 234	44,936	99,193	344,505
1899.....	47,301	1,892,060	5,394	35,060	610	24,176	2,850	39,901	27,067	108,270	82,878	304,332

Year.	Sulphur.		Sulphuric Acid.		Tin.				Whetstones.		Zinc.	
					Ingot, Crude, Old, etc.		Salts.				Metal.	
1895.....	14,709	$264,761	1,566	$17,221	3,038	$972,298	46·0	$11,408	3,559	$106,391	17,156	$1,221,496
1896.....	15,221	273.978	3,522	38,740	3,344	982,001	27·7	6,316	3,851	115,609	17,539	1,403,088
1897.....	21,406	359,942	5,877	58,967	3,467	1,060,933	22·3	4,995	4,151	107,929	16,599	1,394,299
1898.....	20,655	358,316	9,724	97,389	3,769	1,313,016	20·9	5,518	3,490	90,750	17,471	1,712,168
1899.....	23,504	387,938	10,245	102,692	3,004	1,742,610	30·2	10,570	3,717	96,645	15,225	1,887,863

Year.	Zinc.—*Continued.*						Metal Wares Other than Iron and Precious Metals.		Ore and Minerals Unspecified.	
	Bars, Sheets, Wire, etc.		Calamine and Other Ores.		White.					
1895.....	611	$59,215	7,691	$125,156	510	$50,990	1,890	$1,450,400	1,268,675	$1,410,268
1896.....	552	57,714	9,022	119,178	590	59,030	1,979	1,483,200	1,311,950	1,462,936
1897.....	356	37,214	7,863	113,222	577	55,790	2,056	1,613,600	1,557,410	1,731,515
1898.....	453	52,461	14,112	259,659	697	59,783	2,121	1,754,800	1,589,972	1,674,265
1899.....	481	70,996	12,730	254,596	750	74,580	2,292	1,971,600	1,742,492	1,831,760

(*a*) From *Statistik des Answärtigen Handels Oesterreichisch Ungarischen Zollgebiets.*

MINERAL EXPORTS OF AUSTRIA-HUNGARY. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 crown = 20·3 cents.)

Year.	Alum.		Aluminum, Sulphate and Chloride.		Ammonium.				Ammoniacal Liquor.	
					Chloride and Sulphate.		Hydrate.			
1895.....	60	$2,027	231	$4,616	876	$46,400	92	$6,808	413	$2,476
1896.....	47	1,598	267	5,332	2,524	135,444	70	5,165	604	3,622
1897.....	70	2,307	210	4,624	4,188	193,295	39	2,830	592	3,553
1898.....	83	2,729	253	5,557	4,886	229,034	23	1,627	724	4,344
1899.....	54	1,822	233	5,319	7,576	381,887	41	3,046	734	4,406

Year.	Antimony.				Arsenic, Arsenious Acid, and Orpiment.		Asbestos.				Asphalt.			
	Ore.		Regulus.				Crude.		Manufactured.		Rock and Earth.		Mastic and Bitumen.	
1895.....	193	$17,028	369	$51,646	6	$675	122	$5,028	10	$6,000	145	$1,166	1,183	$11,832
1896.....	218	19,184	441	57,291	26	2,646	48	1,995	10	8,000	134	1,057	1,692	16,922
1897.....	289	25,467	359	45,209	16	1,629	56	1,644	19	12,000	102	773	2,593	25,930
1898.....	266	23,417	679	89,694	29	3,276	150	3,567	28	22,149	183	1,413	2,126	21,264
1899.....	562	49,447	340	38,384	47	6,729	71	2,136	60	33,202	1,143	9,984	2,619	41,800

Year.	Barytes, Including Manufactured Product.		Brass, German Silver and Tombac. Crude, Old and Remnants.		Brass, German Silver and Tombac. Bars, Sheets, Wires, Etc.		Chloride of Lime.		Cement.	
1895.....	392	$8,609	1,115	$189,091	459	$142,778	267	$8,854	12,804	$72,197
1896.....	203	6,693	1,469	235,936	399	152,030	114	3,824	16,721	95,291
1897.....	70	2,923	1,699	284,197	680	269,856	111	3,552	19,786	112,536
1898.....	111	3,620	1,879	339,764	839	351,178	113	3,606	23,989	135,861
1899.....	557	3,470	1,824	421,037	910	378,314	203	6,490	38,193	198,606

Year.	Chrome Ore.		Clay Products. Manufactures.		Clay Products. Kaolin and Feldspar.		Clay Products. Potters' and Other Clays.		Coal.	
1895.....	385	$10,000	51,767	$3,205,600	56,203	$ 642,623	37,667	$150,666	640,963	$1,953,536
1896.....	142	3,695	67,270	3,436,400	67,381	896,569	41,276	167,104	658,368	2,000,697
1897.....	153	3,682	55,895	3,280,000	68,609	918,756	46,968	187,872	701,919	2,133,251
1898.....	121	2,653	66,005	3,404,400	74,003	991,308	52,851	211,403	824,730	2,687,796
1899.....	53	1,052	72,104	3,524,200	78,537	1,055,430	61,898	247,594	879,236	2,823,766

Year.	Coal, Lignite.		Coke.		Copper. Ore.		Copper. Crude and Old.		Copper. Bars, Sheets, Plates, etc.		Copper Sulphate.	
1895.....	7,143,234	$9,360,964	119,051	$645,262	17	$531	151	$34,451	354	$100,170	162	$13,600
1896.....	7,562,721	9,728,325	116,608	620,006	12	397	228	53,761	189	59,487	47	4,221
1897.....	8,108,975	10,742,872	145,056	790,594	0·1	3	159	38,232	180	58,991	14	1,305
1898.....	8,351,955	11,749,110	194,289	1,095,885	12	476	173	44,928	266	91,469	29	2,655
1899.....	8,662,788	12.879,387	252,971	1,481,120	74	3,690	534	190,933	298	133,547	66	7,980

Year.	Copperas.		Cryolite.		Fertilizers, Mineral.		Fluorspar.		Glass. Manufactures.		Glass. Remnants.	
1895.....	301	$2,766	11	$2,234	6,266	$62,663	44	$501	50,843	$9,219,200	1,070	$7,490
1896.....	392	3,133	2	494	6,567	65,667	40	509	52,752	9,717,200	1,638	11,468
1897.....	648	6,870	10	2,044	4,498	44,979	27	385	50,082	8,948,000	2,086	14,599
1898.....	539	4,744	23	4,662	4,267	42,673	22	227	50,304	8,689,600	1,904	13,326
1899.....	808	6,384	101	22,086	3,419	27,350	309	3,087	55,539	9,978,800	2,772	19,403

Year.	Gold. Ore.		Gold. Bullion—Kg.		Gold. Old, Remnants, and Dross—Kg.		Gold. Coin—Kg.		Graphite.		Gypsum. Crude.	
1895.....	1	$176	306	$135,448	116,911	$232,992	15,452	$8,754,498	11,923	$200,105	1,496	$6,582
1896.....	45	2,912	381	178,308	131,942	232,448	23,926	13,355,371	13,091	219,676	899	3,957
1897.....	37	2,214	239	110,896	119,336	352,510	33,316	18,324,070	14,229	228,598	662	2,914
1898.....	13	810	27	12,528	137,478	371,760	42,620	23,428,432	17,100	252,235	718	3,160
1899.....	67	5,336	38	17,632	163,160	308,800	22,770	10,523,500	19,451	283,771	633	2,787

Year.	Gypsum.—*Con.* Calcined.		Hydrochloric Acid.		Iron. Ore.		Iron. Pig, Old, etc.		Iron. Manufactures.		Iron and Steel. Bars, Sheets, Wire, etc.	
1895.....	1,439	$14,396	1,460	$12,733	165,402	$595,446	9,786	$176,400	18,698	$4,969,200	9,993	$692,800
1896.....	1,376	12,106	1,246	10,036	214,390	771,804	11,712	204,000	17,674	4,239,600	12,428	870,000
1897.....	1,804	15,875	1,439	12,089	247,856	941,852	12,084	243,600	21,064	4,362,400	17,387	1,296,800
1898.....	2,163	19,039	1,614	13,884	302,317	1,269,730	15,803	261,200	22,724	4,958,000	23,231	1,601,200
1899.....	1,539	12,310	1,495	12,706	326,951	1,503,976	27,738	508,400	35,299	5,241,200	45,720	2,373,800

Year.	Lead. Ash.		Lead. Litharge		Lead. Metal and Alloys.		Lead. Ore.		Lead. Red and Yellow		Lead. White.	
1895.....	118	$2,354	782	$62 536	208	$13.279	3,758	$90,247	24	$1,896	233	$31,647
1896.....	113	2,264	597	47,760	272	18,802	3,076	86,125	33	2,640	171	21,888
1897.....	114	3,181	355	28,376	241	15,863	2,438	78,022	24	2,008	47	6,317
1898.....	100	3,209	188	16,579	545	56,300	2,253	81,122	45	4,132	55	7,796
1899.....	99	3,359	188	16,600	258	21,058	2,502	110,070	(*b*)		40	5,711

Year.	Lime. (Hydraulic and Caustic.)		Manganese Ore.		Millstones.		Mineral Paints.		Nickel, Bars, Sheets, Wires, Etc.		Nickel and Cobalt Ores.	
1895.....	34,698	$152,670	425	$5,955	1,977	$118,596	2,244	$34,581	54	$58,122	139	$9,803
1896.....	76,895	351,238	701	8,696	1,831	109,842	1,700	25,826	273	273,640	113	9,278
1897.....	83,110	379,166	622	8,214	1,773	106,386	1,621	24,398	170	145,184	117	11,088
1898.....	89,067	407,569	1,961	23,531	2,109	126,546	2,153	32,580	76	66,316	121	4,803
1899.....	85,570	359,486	1,127	14,426	1,904	106,613	2,061	31,533	38	35,903	75	6,266

Year.	Nitric Acid.		Oxide. (Potash.)		Ozokerite.		Peat and Peat Coke.		Petroleum.			
									Crude.		Refined.	
1895.....	418	$27,675	5,665	$386,634	5,054	$597,577	3,753	$10,958	1,454	$21,738	3,863	$112,049
1896.....	360	23,808	4,164	282,414	5,722	766,681	2,701	7,886	1,815	20,724	23,106	397,427
1897.....	310	20,902	5,997	381,395	5,153	762,570	1,655	4.832	1,600	15,364	13,082	213,700
1898.....	294	19,384	7,252	465,479	4,462	696,088	3,400	9,929	1,076	10,330	3,062	46.838
1899.....	420	27,313	10,313	780,568	5,441	859,600	4,010	11,710	1,823	21,872	7,778	147,784

Year.	Potassium Salt Chloride.		Pyrites.		Quicksilver.		Salt.		Silica. (Quartz and Quartz Sand.)		Silver.	
											Bullion—Kg.	
1895.....	1,074	$30,069	383	$2,069	493	$390,694	6,554	$39,327	30,213	$90,413	2,130	$38,766
1896.....	1,026	28,734	341	1,842	569	423,634	11,811	70,868	32,844	98,727	2,360	42,952
1897.....	1,005	36,166	255	1,379	529	408,697	182	1,091	31,347	94,727	4,120	66,250
1898.....	994	35,798	3,039	16,413	468	378.548	240	1,439	39,033	117,806	4,870	78,310
1899.....	974	35,078	5,201	29,123	490	456,680	117	705	68,412	210,142	48,240	849,024

Year.	Silver.—*Continued.*						Slag and Slag Wool.		Slate, Roofing and Other.	
	Coin—Kg.		Old and Dross. Kg.		Ore.					
1895.....	47,275	$805,826	88,770	$53,500	(*b*)		52,688	$168,602	4,569	$101,900
1896.....	182,950	3,075,482	123,220	76,952	16	$832	83,187	266,200	4,602	102,970
1897.....	114,560	1,681,500	116,700	68,648	(*b*)		65,966	131,931	4,581	102,461
1898.....	26,130	378,376	121,400	71,280	1	56	75,018	180,043	4,972	110,862
1899.....	15,240	221,732	84,800	180,490	12	468	109,180	393.048	5,535	124,080

Year.	Sodium.										Stone.	
	Carbonate.		Carbonate, Calcined.		Nitrate, Crude.		Salts, Potassium Nitrates, Refined.		Sulphate.		Lithographic.	
1895.....	278	$3,933	1,504	$32,417	146	$6,841	224	$22,410	661	$7,665	4	$181
1896.....	427	5,124	2,487	59,955	55	2,306	160	15,970	2.291	20,617	6	285
1897.....	599	7,782	3,372	86,074	61	2,562	120	9,728	6,910	55,281	22	1,115
1898.....	952	13,140	2,895	60,384	33	1,344	180	12,931	7,248	58,208	8	405
1899.....	1,894	25,377	1,502	31,534	88	3,593	188	12,565	5,716	45,853	11	565

Year.	Stone.—*Continued.*								Sulphur.		Sulphuric Acid.	
	Limestone.		Marble.		Paving.		Not Elsewhere Specified.					
1895.....	33,479	$66,959	2,737	$32,845	29,392	$170,475	241.040	$582,193	989	$20,054	6,466	$87,855
1896.....	23,249	46,498	3,595	43,135	30,577	177,348	216,666	529,770	1,231	22,822	6,212	78,980
1897.....	11,373	22,747	2,994	35,932	38,256	221,886	223,321	528,538	947	18,950	7,903	94,153
1898.....	25,117	50,233	2,954	35,452	54,953	318,727	252,229	624,070	923	18,464	9,880	97,911
1899.....	11,052	22,105	4,096	65,542	67,212	389,828	239,819	576,265	885	17,694	12,422	144,730

Year.	Tin.						Whetstones.		Zinc.			
	Ingot and Old.		Bars, Plates, Sheets, etc.		Ash.				Ash.		Metal.	
1895.....	53	$34,451	90	$30,736	248	$57,466	2,169	$78,979	179	$12,145	504	$37,785
1896.....	130	53.761	78	25,486	281	60.653	2,035	69,176	277	18,849	1,256	95,471
1897.....	87	20,880	75	25,534	306	66,009	2,323	73,748	197	14,198	770	48,182
1898.....	96	21.628	72	26,353	324	81,598	2,316	68.730	298	16,677	1,184	87,231
1899.....	167	77,339	77	40,280	273	95,410	2,215	75,303	73	4,659	1,614	154,973

Year.	Zinc.—*Continued.*						Metal Wares Other than Iron and Precious Metals.		Ores and Minerals Unspecified.	
	Ores.		Sheets, etc.		White.					
1895.....	7,491	$107,870	1,158	$117,217	1,688	$148,553	3,807	$2,741,600	79,582	$1,188,268
1896.....	9,453	151,242	1,139	126,195	1,825	153,325	4,362	2,944,000	45,848	628,762
1897.....	12,914	247,950	993	106,232	1,673	140,532	4,486	3,130,800	47,883	680,364
1898.....	14,065	337,562	757	96,141	1,240	114,089	4,841	3,234,400	67,531	914,134
1899.....	20,461	613,818	1,313	211,468	1,096	100,823	5,250	4,078,400	82,865	1,081,906

(*a*) From *Statistik des Answärtigen Handels des Oesterreichisch Ungarischen Zollgebiets.* (*b*) Not reported.

MINERAL PRODUCTION OF BOSNIA AND HERZEGOVINA. (*a*) (METRIC TONS AND DOLLARS.)

Year.	Chrome Ore.		Copper.		Copper Ore.	Iron, Pig.		Iron Ore.	Lignite.		Manganese Ore.		Quicksilver.	Salt.	
1896	443	$5,426	206	(*b*)	(*b*)	10,120	$118,063	(*b*)	222,724	$187,870	6,821	$45,019	(*b*)	13,720	$384,157
1897	396		135		3,847	15,606		37,095	229,643		5,344	33,772	(*b*)	13,919	389,729
1898	458		156		3,760	15,263		57,935	270,752		5,320		4·0	14,496	
1899	200		180		3,980	13,730		67,030	303,000		5,270		3·3	15 030	
1900	...		...												

(*a*) From *Oesterr. Zeits. für Berg-, Hütten und Salinenwesen*, except the figures for 1897 and 1898, which were furnished by the "Bosnisches Bureau des K. und K. gemeinsamen Ministeriums." Besides the substances specified in the table there was also produced: In 1897, fahlore, 40 tons; in 1898 452 tons; in 1899, 620 tons. Iron pyrites, in 1898, 3,670 tons. (*b*) Not reported.

BELGIUM.

THE most important articles of mineral production in Belgium are coal, iron, lead, zinc, manganese ore and phosphate of lime. Developments in these industries are described specifically under the respective captions elsewhere in this volume. The official statistics of production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f.=$1.)

Year.	Iron Ore.		Lead Ore.		Manganese Ore.		Pyrites.		Zinc Ore.				Totals.
									Blende.		Calamine.		
1895.....	312,637	$296,090	220	$5,100	22,478	$57,254	3,510	$7,230	8,080	$72,510	4,150	$40,340	$478,524
1896.....	307,031	283,564	70	1,610	23,265	69,004	2,560	5,370	7,070	71,280	4,560	48,970	479,780
1897.....	240,774	252,902	108	3,230	28,372	68,540	1,828	3,990	6,804	74,340	4,150	41,270	444,272
1898.....	217,370	211,644	133	4,301	16,440	42,300	147	177	7,350	98,262	4,125	51,250	407,934
1899.....	201,445	214,620	137	6,540	12,120	31,160	283	380	c9,460	171,080	(*d*)		423,780

PRODUCTION OF MINERAL FUEL IN BELGIUM.

Year.	Coal.							Coke.		
	Quantity. Metric Tons.	Value.		Profit.		Number of Workmen.	Average Annual Wages.	Ovens, Active.	Number of Workmen.	Consumption of Coal. Metric Tons
		Total.	Per Ton	Total.	Per Ton					
1895	20,457,604	$38,671,540	$1·89	$1,659,480	$·082	118,957	$189	3,233	2,130	2,358,663
1896.....	21,252,370	40,402,020	1·90	2,179,400	·102	119,246	196	3,555	2,415	2,709,720
1897.....	21,492,446	44,134,420	2·05	3,911,350	·182	120,382	205	3,845	2,566	2,968,620
1898.....	22,088,335	48,578,780	2·20	4,654,921	·210	122,846	219	4,028	2,519	2,944,096
1899.....	22,072,068	54,888,780	2·49	(*d*)		125,258	(*d*)	(*d*)	(*d*)	(*d*)

Year.	Coke—*Continued.*			Briquettes from Coal.					
	Quantity. Metric Tons.	Value.		Number of Works, Active.	Number of Workmen.	Consumption of Coal. Metric Tons	Quantity. Metric Tons.	Value.	
		Total.	Per Ton					Total.	Per Ton
1895.....	1,749,109	$4,810,050	$2·75	38	(*b*)	(*b*)	1,217,795	$2,956,806	$2·43
1896.....	2,004,430	5,700,599	2·84	36	1,334	1,092,340	1,213,760	2,910,596	2·40
1897.....	2,207,840	7,572,891	3·43	37	(*b*)	1,129,791	1,245,114	3,112,785	2·50
1898.....	2,161,162	8,104,357	3·75	37	1,191	1,227,720	1,351,884	3,623,049	2·68
1899.....	(*d*)			(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	

METALLURGICAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.

Year.	Iron, Crude.								
	Forge Pig.			Foundry Pig.			Bessemer Pig.		
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
		Total.	Per Ton		Total.	Per Ton		Total.	Per Ton
1895	329,750	$ 2,949,180	$8·94	85,450	$747,560	$8·75	161,606	$1,809,020	$11·07
1896	362,451	3,734,840	10·30	84,275	805,880	9·56	193,518	2,284,720	11·81
1897	426,332	4,653,486	10·91	78,410	912,300	11·63	183,701	2,377,210	12·94
1898	308,875	3,329,775	10·78	93,645	1,000,720	10·69	173,085	2,243,380	12·96
1899	*d*))			(*d*)			(*d*)		

Year.	Iron, Crude—*Continued.*						Iron, Manufactures of.			
	Thomas Pig.			Total Pig.			Bar, Crude.		Rails.	
	Quantity.	Value.		Quantity.	Value.					
		Total.	Per Ton		Total.	Per Ton				
1895	252,428	$2,536,020	$10·05	829,234	$8,041,780	$9·65	76,101	$1,718,760	525	$12,820
1896	307,779	3,336,580	10·84	959,414	10,316,180	10·75	81,394	2,030,500	1,027	27,720
1897	333,958	4,001,380	11·98	1,035,037	12,144,076	11·73	108,608	2,801,200	1,443	40,400
1898	397,851	4,898,140	12·31	979,755	11,580,970	11·82	123,993	3,216,770	837	23,350
1899	(*d*)			1,036,185	(*d*)		(*d*)		(*d*)	

Year.	Iron, Manufactures of—*Continued.*						Lead, Crude.		Silver—Kg.	
	Sheet and Plate.		Wrought.		Other Manufactures.					
1895	109,209	$3,189,728	741	$56,390	259,323	$6,168,140	15,573	$840,760	31,543	$686,000
1896	112,597	3,365,698	851	50,240	298,163	7,326,770	17,222	1,029,980	28,509	637,900
1897	100,252	3,148,800	872	47,800	263,644	6,834,000	17,023	1,101,760	30,073	631,422
1898	91,686	2,831,800	993	61,440	267,521	7,061,230	19,330	1,252,420	116,035	2,477,170
1899	(*d*)		(*d*)		(*d*)		(*d*)		(*d*)	

Year.	Steel.									
	Ingots, Cast and Blooms.		Rails.		Tires.		Sheet.		Forge.	
1895	454,619	$6,885,200	122,357	$2,508,160	7,359	$259,790	179,249	$3,916,260	4,551	$141,830
1896	598,974	10,102,490	147,183	3,174,780	10,497	367,670	268,009	6,070,020	6,702	204,910
1897	616,541	11,104,800	136,911	3,295,800	10,870	427,200	272,839	6,743,400	23,104	586,400
1898	653,523	11,877,040	117,751	2,868,960	10,953	408,920	314,150	7,981,610	17,902	516,700
1899	(*d*)		(*d*)		(*d*)		(*d*)		(*d*)	

Year.	Steel—*Continued.*						Zinc.			
	Plates.		Wire.		Total.		Crude.		Sheet.	
1895	42,444	$1,349,144	11,987	$308,670	367,947	$8,483,854	107,664	$7,699,340	34,081	$2,688,400
1896	64,653	2,216,640	22,267	591,820	519,311	12,625,840	113,361	9,182,440	36,238	3,244,610
1897	64,366	2,354,000	19,567	558,400	527,617	13,965,600	116,067	9,936,090	37,011	3,450,710
1898	87,219	2,978,590	19,753	567,620	567,728	15,322,000	119,671	11,881,660	35,587	3,841,190
1899	(*d*)		(*d*)		729,820		(*d*)		(*d*)	

QUARRY PRODUCTION OF BELGIUM. (*a*) (VALUES IN DOLLARS; 5 f. = $1.)

Year.	Barytes. Metric Tons.		Chalk, Marl. Cubic Meters.		Clay. Metric Tons.		Feldspar. Cubic Meters.		Flint for Earthenware. Cubic Meters		Flint and Gravel for Ballast. Cubic Meters.		Mineral Paints. Ochers. Cu. Met.	
1895	32,750	$45,860	100,160	$31,200	195,485	$272,940	1,900	$1,560	24,870	$20,000	202,590	103,200	500	$2,000
1896	25,000	35,000	191,100	66,400	83,020	84,500	2,000	3,200	23,450	19,160	244,050	123,140	700	2,800
1897	23,000	32,200	204,600	90,680	270,715	359,952	1,100	1,940	23,050	17,720	235,495	110,819	350	1,450
1898	21,700	30,380	287,805	136,220	287,805	416,240	1,000	1,980	22,150	17,700	360,960	177,700	290	1,180
1899	25,900	36,260	351,800	115,540	291,125	398,968	1,525	3,350	25,185	20,690	258,835	121,838	300	1,200

Year.	Phosphate of Lime. Cubic Meters.		Sand. Cubic Meters.		Slate. Pieces.	Slate. Cubic Meters	Slate. Total Value.	Building Stone—Cubic Meters. Conglomerate.		Dolomite.		Flagstones. Square Meters.	
1895...	506,730	$683,140	381,170	$158,120	33,652,000	690	$251,720	245	$6,680	(b)		95,137	29,640
1896...	297,470	537,320	418,720	162,960	35,980,000	1,150	269,500	160	4,000	21,500	$7,200	131,400	91,720
1897...	350,056	436,762	559,141	237,196	41,422,000	1,445	335,780	220	5,500	52,720	13,908	107,572	71,646
1898...	156,920	303,230	287,805	136,220	42,311,000	210	350,660	180	4,680	37,100	13,068	170,672	157,650
1899...	190,090	342,180	627,770	241,698	44,167,000	200	358,112	200	5,400	56,400	19,838	144,330	127,355

Year.	Stone. Freestone.		Limestone.		Limestone for Flux. Cubic Meters.		Marble. Cubic Meters.		Paving Stones. *Pieces.*		Whetstones and Hones—*Pieces.*	
1895	137,353	$2,385,660	2,488,840	$2,135,940	163,800	$87,400	12,790	$424,240	92,378,800	$1,575,160	70,000	$11,120
1896	152,420	2,742,300	2,646,305	2,143,500	164,900	75,360	16,315	544,680	102,295,950	1,793,720	45,850	6,820
1897	181,746	3,076,924	3,010,877	2,730,730	225,300	89,085	17,797	471,954	95,542,700	1,739,875	43,150	16,740
1898	215,417	3,177,534	2,968,997	2,580,695	212,685	74,740	16,610	547,100	108,025,000	2,016,314	89,150	22,590
1899	139,294	3,249,146	3,238,875	2,735,025	195,505	77,956	17,740	601,170	114,103,900	2,236,411	82,100	14,160

(*a*) From *Statistiques des Mines, Minières, Carrières, et Usines Métallurgiques*, by Emil Harzé. Belgium also produced, in 1896, manganese pig-iron, 11,391 tons, $154,160; kaolin, 130,960 cu. m., $213,560; and in 1897, manganese pig-iron, 12,636 tons, $199,700. (*b*) Not stated in the report. (*c*) Includes output of calamine. (*d*) Statistics not yet available.

MINERAL IMPORTS OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Ashes.		Cement.		Chemical Products. Soda Salts.		Chemical Products. Not Specified.	Clay Products. (*e*). Terra Cotta. *Pieces.*		Clay Products. (*e*). Common Pottery.	
1895.....	6,173	$24,694	23,198	$139,190	184,306	$14,630,218	$4,390,884	40,531	$243,185	2,344	$117,216
1896.....	6,747	26,988	30,565	183,392	194,202	11,989,011	5,438,285	*b*85,486	629,221	2,065	103,231
1897.....	10,870	43,481	17,681	113,160	181,676	7,419,315	6,048,423	*b*86,493	549,631	2,115	105,756
1898.....	8,199	32,796	34,039	231,471	152,164	5,033,039	6,896,420	*b*92,149	610,058	2,007	104,436
1899.....	15,818	63,271	18,649	128,675	249,756	7,996,717	6,431,947	*b*99,156	633,955	2,856	102,098

Year.	Clay Products—*Con* Earthenware.	Clay Products—*Con* Porcelain	Coal.		Coal Briquettes.		Coke.		Copper and Nickel. Crude.	
1895.....	$254,547	$155,283	1,530,364	$4,713,521	3,452	$11,046	362,834	$1,327,972	10,480	$2,431,424
1896.....	*c*272,894	*d*177,207	1,693,376	5,249,466	1,561	5,151	260,273	976,024	15,506	3,597,466
1897.....	*c*298,535	*d*188,434	2,017,344	6,455,501	632	2,212	269,606	1,159,306	14,821	3,556,943
1898.....	179,866	345,067	2,202,517	7,268,306	1,756	6,585	180,590	784,590	14,947	5,082,274
1899.....	438,072	233,394	2,844,274	10,523,814	10,722	43,960	296,508	1,482,540	8,327	3,330,798

Year.	Copper and Nickel.—*Con.* Hammered, Drawn or Rolled.		Copper and Nickel.—*Con.* Wrought.	Glass and Glassware. Common (Bottles, Broken Glass, etc.)	Glass and Glassware. All Other Kinds.	Gold (Including Platinum). Ore—Kg.		Gold (Including Platinum). Unwrought—Kg.		
1895.....	926	$268,462	$168,720	6,078	$187,035	$441,558	65	$429	2,714	$1,869,403
1896.....	1,109	321,718	188,931	6,980	213,380	541,225	93	614	4,923	3,390,962
1897.....	1,418	405,576	193,242	4,699	143,130	664,176			3,824	2,633,971
1898.....	1,821	765,000	205,705	4,247	99,608	635,021	8,390	55,374	1,282	883,041
1899.....	2,174	999,985	226,853	3,757	90,473	651,208	51	337	1,136	782,477

Year.	Gold.—*Continued.* Coin.	Gold.—*Continued.* Jewelry, etc.	Guano.		Iron and Steel Filings.		Iron. Ore.		Iron. Pig.	
1895.....	$616,280	$523,491	43,017	$1,806,725	61·6	$492	1,857,624	$3,529,485	225,037	$2,326,123
1896.....	599,540	757,507	25,946	1,037,846	11·1	93	2,069,676	3,932,385	324,389	3,897,069
1897.....	1,726,700	701,535	5,162	185,825	26·4	227	2,544,377	4,834,316	302,193	3,815,918
1898.....	372,000	840,593	10,657	383,664	18·0	158	2,252,553	4,279,850	317,829	3,782,157
1899.....	744,000	965,170	15,072	579,991	184·0	1,748	2,621,152	5,242,304	362,458	5,685,163

Year.	Iron.—*Continued.*						Lead.			Lime.	
	Old.		Hammered, Drawn or Rolled.		Wrought.		Pig.		Manufactures.		
1895.....	22,817	$273,809	17,616	$462,134	4,932	$362,567	45,594	$2,370,874	$21,097	9,083	$17,893
1896.....	53,802	688,668	22,812	646,150	6,118	469,031	35,221	1,937,173	17,231	11,522	22,699
1897.....	51,985	670,603	26,054	792,873	6,336	491,296	43,840	2,630,429	91,580	13,184	26,236
1898.....	52,298	690,320	25,470	781,167	14,918	879,347	54,867	3,489,549	50,728	12,674	25,349
1899.....	61,510	922,647	34,960	1,127,656	6,934	559,899	60,649	4,184,756	191,508	12,811	28,184

Year.	Petroleum.				Resins and Bitumens, Not Specified.		Salt.			
	Crude.		Refined.				Crude.		Refined.	
1895.....	1,824	$25,540	159,980	$5,759,266	226,133	$11,306,672	81,188	$487,126	40,625	$406,245
1896.....	95	1,336	158,979	5,405,275	216,278	10,813,881	92,408	554,449	38,785	387,852
1897.....	988	13,831	149,501	4,843,844	237,570	11,878,487	96,805	580,827	39,193	391,926
1898.....	382	7,446	161,281	5,419,070	269,914	13,495,710	92,300	553,804	50,136	501,364
1899.....	2,479	49,590	166,404	5,990,562	264,718	13,235,887	81,324	487,945	50,647	506,475

Year.	Silver.						Steel.					
	Ore—Kg.		Bullion—Kg.		Coin.	Jewelry, etc.	Ingot.		Bars, Sheets, and Wire.		Wrought.	
1895.....	1,297,070	$155,648	7,936	$206,336	$2,793,680	$343,840	18,405	$294,478	17,582	$538,880	1,136	$283,031
1896.....	1,476,582	177,190	8,980	233,480	6,461,840	415,967	28,435	561,744	15,263	479,341	936	233,924
1897.....	2,533,237	253,324	467,851	9,357,020	*f* 2,083,040	460,244	25,370	518,271	25,869	834,766	1,147	286,415
1898.....	461,914	46,191	299,369	5,987,990	7,655,200	449,244	25,142	526,442	24,761	805,918	1,013	256,925
1899.....	2,522,950	252,295	105,723	2,114,460	14,272,080	520,070	11,666	256,737	33,552	1,761,345	1,070	275,521

Year.	Stone.								Sulphur.		
	Roofing Slate. *1,000 Pieces.*		Building Stone, Including Marble and Alabaster.		Cut, Polished, etc.	Paving.		All Other Kinds.			
1895.....	37,720	$150,879	31,156	$523,114	$53,450	4,249	$14,023	83,569	$919,263	18,438	$590,029
1896.....	38,209	152,834	40,511	891,237	61,769	6,163	22,187	81,360	894,964	14,399	403,177
1897.....	38 754	162,765	47,929	1,054,432	111,313	13,197	47,509	182,950	1,097,417	13,261	371,307
1898.....	38,216	198,724	45,544	1,093,052	63,665	8,926	37,489	239,281	1,312,764	13,322	373,037
1899.....	35,888	186,616	49,498	1,484,940	83,372	7,835	37,608	216,231	1,405,392	8,449	236,567

Year.	Tin.			Tin Plate.			Zinc.			Ores, Crude Not Elsewhere Specified.
	Ingot.		Manufactures.	Unwrought.		Wrought.	Ingot.		Manufactures.	
1895.....	3,216	$1,286,230	$3,501	2,046	$151,511	$23,712	8,551	$615,643	$13,095	$8,361,581
1896.....	4,617	1,662,044	2,845	3,203	243,403	27,425	20,182	1,614,588	11,230	10,227,349
1897.....	1,609	547,118	2,634	3,875	294,533	22,972	16,320	1,387,218	10,661	13,048,392
1898.....	1,208	628,084	2,545	3,848	256,180	29,990	17,441	1,757,103	11,575	13,497,359
1899.....	1,113	667,504	4,373	3,900	306,564	46,437	11,058	1,150,063	11,436	17,728,858

(*a*) From *Statistique de la Belgique; Tableau General du Commerce avec les Pays, Etrangers, Brussels.* (*b*) In metric tons. (*c*) Corresponding in 1896 to 3,668 metric tons, and in 1897 to 3,713 metric tons. (*d*) Corresponding in 1896 to 824 metric tons, and in 1897 to 815 metric tons. (*e*) There was imported in 1897 also slabs of pottery for paving, building, etc., 7,755 metric tons, $172,795. (*f*) Corresponding to 52,076 kg.

MINERAL EXPORTS OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Ashes.		Cement.		Chemical Products.			Clay Products.			
					Soda Salts.		Not Specified.	Terra Cotta. *No. of Pieces.*		Common Pottery.	
1895.....	1,030	$4,121	273,807	$1,642,845	55,089	$3,965,041	$5,555,916	127,413	$764,481	3,463	$173,140
1896.....	1,084	4,338	277,615	1,665,690	42,857	2,298,603	6,819,396	*b*302,526	1,913,054	2,628	131,394
1897.....	2,675	10,701	322,024	2,060,951	59,054	2,202,874	7,236,116	*b*294,815	1,773,837	3,197	159,867
1898.....	615	2,459	419,132	2,850,092	106,252	2,718,179	7,300,805	*b*247,970	1,497,938	3,186	81,066
1899.....	400	1,598	445,602	3,074,655	109,253	2,790,617	6,431,947	*b*328,733	1,974,565	3,216	96,153

Year.	Clay Products.—*Continued.*				Coal.		Coal Briquettes.		Coke.	
	Earthenware.		Porcelain.							
1895.....	4,048	$809,509	400	$352,589	4,661,477	$14,357,349	459,702	$1,471,046	870,983	$3,187,798
1896.....	4,692	513,950	586	54,332	4,649,799	14,414,377	459,974	1,517,914	863,067	3,236,501
1897.....	4,905	534,532	264	45,395	4,448,544	14,236,341	615,074	2,152,759	909,486	3,910,789
1898.....	10,981	640,025	218	35,332	4,579,955	15,113,851	666,265	2,498,493	878,435	3,865,114
1899.....	4,417	483,133	264	39,759	4,568,938	16,905,071	525,625	2,155,062	1,008,740	5,043,700

Year.	Copper and Nickel.					Glass and Glassware.				
	Crude.		Hammered, Drawn or Rolled.		Wrought.	Common (Bottles, Broken Glass, etc.).		Plate.	All Other Kinds	
1895.....	5,205	$1,207,508	2,558	$741,944	$129,892	4,181	$42,923	$2,768,243	156,304	$7,400,444
1896.....	11,700	2,714,477	2,073	601,277	168,524	3,647	26,574	3,468,668	178,611	12,194,434
1897.....	9,994	2,398,659	1,996	570,761	198,665	3,546	26,468	3,761,219	174,232	11,448,889
1898.....	8,511	2,893,856	1,770	743,802	161,726	2,747	37,480	3,007,865	25,226	3,088,285
1899.....	4,665	1,866,089	2,111	970,882	251,060	3,850	88,283	4,942,298	196,842	12,553,516

Year.	Gold (Including Platinum).				Guano.		Iron and Steel Filings.		Iron.	
	Unwrought—Kg.		Coin.	Jewelry, etc.					Ore.	
1895.....	893	$615,098	$3,547,640	$77,426	18,968	$796,644	1,488	$11,904	325,809	$619,036
1896.....	3,713	2,557,514	2,666,620	75,570	14,633	585,303	7,025	59,007	389,235	739,546
1897.....	2,547	1,754,374	605,120	126,385	14,044	505,585	534	4,595	410,817	780,552
1898.....	1,231	817,213	578,120	118,897	21,626	778,542	407	3,581	384,047	729,683
1899.....	504	347,753	998,200	118,916	18,213	655,669	239	2,270	318,415	636,830

Year.	Iron.—*Continued.*								Lead.	
	Pig.		Old.		Hammered, Drawn or Rolled.		Manufactures.		Pig.	
1895.....	33,237	$912,301	12,519	$150,228	271,066	$6,697,454	39,985	$2,983,007	39,996	$2,079,800
1896.....	38,465	1,132,480	18,416	235,725	343,072	9,072,611	44,952	3,497,287	31,366	1,725,144
1897.....	42,554	1,325,352	17,590	226,911	356,835	10,097,254	44,521	3,501,950	35,988	2,159,293
1898.....	16,789	223,453	23,326	309,676	234,562	4,155,448	74,889	4,984,032	40,302	2,563,246
1899.....	43,304	1,418,941	32,504	487,557	385,878	10,955,330	73,743	4,879,020	41,618	2,871,662

Year.	Lead.—*Con.*	Lime.		Petroleum.				Resins and Bitumens, not Specified.	
	Wrought.			Crude.		Refined.			
1895.....	$18,192	436,635	$860,172	2,312	$32,364	29,239	$1,052,591	76,087	$3,804,331
1896.....	36,821	477,213	940,110	2	23	29,321	996,913	86,906	4,345,315
1897.....	33,286	520,588	1,035,969	1	15	18,088	586,067	92,591	4,629,538
1898.....	16,450	546,199	1,092,399	782	13,256	19,556	657,067	107,806	5,390,353
1899.....	37,022	537,357	1,182,186	2,146	42,924	25,970	934,937	112,392	5,019,622

Year.	Salt.				Silver.						
	Crude.		Refined.		Ore—Kg.		Bullion—Kg.		Coin—Kg.		Jewelry, etc.
1895.....	2,136	$12,814	117	$1,172	19,400	$2,328	45,299	$1,177,774	48,326	$1,933,040	$51,452
1896.....	1,434	8,604	129	1,287	19,400	2,328	40,118	1,043,068	16,696	667,840	137,137
1897.....	493	2,959	231	2,309	423,160	42,316	57,933	1,158,660	521	20,851,320	189,959
1898.....	298	1,789	386	3,864	595	59	107,385	2,125,700	327	13,083,640	127,194
1899.....	506	3,037	885	8,850	116	12	54,358	1,087,160	337,079	13,483,160	214,175

Year.	Steel.						Stone.				
	Ingot.		Bars, Sheets and Wire.		Manufactures.		Roofing Slate. *1,000 Pieces.*		Building Stone, Including Marble and Alabaster.		Cut, Polished, etc.
1895.....	1,315	$21,038	170,328	$4,052,108	27,438	$5,508,067	15,237	$106,657	147,679	$1,004,216	$645,690
1896.....	1,145	23,272	179,873	4,597,877	38,306	7,843,777	15,435	111,130	161,298	1,290,387	922,147
1897.....	1,201	22,302	183,386	4,842,221	37,353	7,764,848	17,304	138,428	187,180	1,591,033	934,286
1898.....	1,018	19,397	175,249	4,856,964	33,652	6,464,909	16,948	152,534	178,249	1,742,491	861,015
1899.....	1,259	26,036	155,815	4,603,643	31,194	6,151,759	15,316	137,843	164,952	2,144,381	948,090

Year.	Stone.—*Continued.*				Sulphur.		Tin.		
	Paving.		All Other Kinds.				Ingot.		Manufactures.
1895.....	134,838	$ 889,930	730,863	$2,923,451	4,576	$146,423	1,051	$420,453	$1,176
1896.....	154,737	1,145,052	796,231	3,184,926	5,335	149,371	1,055	379,732	873
1897.....	153,504	1,197,335	773,531	3,248,832	6,041	169,157	347	118,089	839
1898.....	159,455	1,339,421	917,654	4,221,212	6,355	177,960	508	263,982	2,394
1899.....	150,993	1,449,530	834,528	4,172,641	6,769	189,533	659	395,479	1,511

Year.	Tin Plate.			Zinc.			Ores Not Specified.
	Unwrought.		Wrought.	Ingot.		Manufactures.	
1895.....	1,750	$133,016	$21,693	88,316	$6,358,748	$54,210	$4,161,023
1896.....	3,952	309,625	11,750	100,369	8,029,501	56,349	4,236,703
1897.....	1,191	90,545	15,216	100,228	8,519,380	90,749	6,216,589
1898.....	973	74,963	10,562	108,507	10,807,313	102,583	7,030,013
1899.....	1,436	112,831	19,566	101,244	10,529,376	109,762	5,720,528

(*a*) From *Statisque de la Belgique: Tableau General du Commerce avec les Pays Etrangers.* (*b*) Metric tons.

CANADA.

THE mineral statistics of the Dominion of Canada as collected by the Geological Survey and the Bureaus of Mines of the various provinces, are summarized in the following tables:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Arsenic.		Asbestos and Asbestic.		Barytes.		Cement—*Barrels.* Natural Rock.		Cement—*Barrels.* Portland.		Chromite.	
1896....	*Nil.*		11,113	$429,856	131	$715	70,705	$60,500	78,385	$141,151	2,124	$27,004
1897....	*Nil.*		27,617	445,368	518	3,060	85,450	65,893	119,763	209,380	2,392	32,474
1898....	*Nil.*		21,577	486,227	971	5,258	87,125	73,412	163,084	324,168	1,833	24,252
1899....	52	$4,872	22,938	483,299	653	4,402	131,387	119,508	255,366	513,983	1,796	23,760
1900....	275	22,725	27,797	763,431	1,207	7,575	123,428	99,994	283,124	545,826	2,118	27,000

Year.	Clay. Fire Clay.		Clay. Pottery	Clay. Terra-Cotta.	Clay. Tile and Sewer Pipe. (*d*)	Coal.		Coke. (*e*)		Copper (In Ore, etc.). (*f*)	
1896....	764	$1,805	$163,427	$83,855	$378,875	3,398,091	$7,226,462	45,014	$110,257	4,260	$1,021,960
1897....	1,921	5,759	129,629	155,595	389,250	3,434,756	7,303,597	55,044	176,457	6,033	1,501,660
1898....	*b*1,969	5,000	135,000	167,902	166,421	3,785,408	8,227,958	65,721	219,200	8,146	2,159,556
1899....	543	1,295	200,000	220,258	161,546	4,142,242	9,040,058	91,463	350,022	6,840	2,655,319
1900....	1,129	4,130	200.000	259,450	231,525	4,837,337	12,668,475	142,555	649,140	8,582	3,063,119

Year.	Feldspar. (*g*)		Gold—Kg. (*h*)		Graphite.		Grindstones.		Gypsum.		Iron Ore.	
1896....	882	*i*$2,583	4,145	$2,754,774	126	$9,455	3,368	$33,310	187,818	$178,061	83,377	$191,557
1897....	1,270	3,290	9,380	6,027,016	396	16,240	4,148	42,340	217,392	244,531	50,000	130,290
1898....	2,268	6,250	20,613	13,700,000	(*q*)	11,098	(*q*)	39,465	198,908	230,440	52,763	152,510
1899....	2,722	6,000	31,673	21,049,730	1,105	16,179	4,092	43,265	221,869	257,329	69,997	248,372
1900....	(*q*)		42,008	27,916,752	1,744	30,940	5,034	53,450	228,614	259,009	*j* 32,103	583,158

Year.	Lead (In Ore, etc.). (*k*)		Lime—*Bushels.*		Manganese Ore.		Mica.	Mineral Paints. (Ochers.)		Mineral Waters.
1896....	10.977	$721,159	(*q*)	$650,000	112	*i*$3,975	$60,000	2,043	$16,045	$111,736
1897....	17,698	1,396,853	(*q*)	650,000	14	1,166	76,000	3,542	23,560	(*q*)
1898....	14,477	1,206,399	(*q*)		45	1,600	117,598	2,124	18,600	155,000
1899....	9,917	977,250	(*q*)		279	3,960	163,000	3,555	19,900	100,000
1900....	28,654	2,760,521	(*q*)		(*q*)		166,000	1,783	15,398	75,000

Year.	Natural Gas.	Nickel (In Ore, etc.). Kg.		Petroleum, Crude. *Barrels.* (*m*)		Phosphate (Apatite).		Platinum.	Pyrites.	
1896	$276,301	1,540,920	$1,188,990	726,822	$1,155,647	517	$3,420	$750	30,586	$101,155
1897.....	325,873	1,813,321	1,399,176	709,857	1,011,546	824	3,984	1,600	35,299	116,730
1898.....	320,000	2,502,808	1,820,838	700,790	981,106	665	3,665	(*q*)	29,228	128,872
1899.....	387,271	2,605,461	*r*2,067,840	808,570	1,202,020	2,732	18,000	835	25,117	110,748
1900.....	417.094	3,212,497	*r* 3,327,707	710.498	1,151,007	1,284	7,105	(*q*)	36,316	155,164

Year.	Sand and Gravel (Exports).		Sand. (Moulding.)		Salt.		Silver (In Ore, etc.)—Kg. (*n*)		Slate.	Soapstone.	
1896.....	203,909	$80,110	5,207	$11,478	39,880	$169,693	99,696	$2,149,503	$53,370	372	$1,230
1897.....	118,768	76,729	4,976	10,931	46,583	225,730	172,891	3,323,395	42,800	142	350
1898.....	(*q*)		9,591	21,038	51,839	248,639	137,911	2,583,298	40,791	(*q*)	
1899.....	(*q*)		12,450	27,430	51,796	234,520	95,762	1,834,371	33,406	408	1,960
1900.....	(*q*)		(*q*)		56,296	279,458	138,301	2,730,598	12,100	381	1,365

Year.	Stone.								Various Products. (*p*)	
	Brick, Stone, etc.	Flagstones. *Sq. Ft.*	Granite.		Limestone for Flux.		Marble.			
1896.....	$1,000,000	(*q*)	$6,710	16,980	$106,709	33,985	$36,140	203	$2,405	$647,997
1897.....	*b*1,000,000	(*q*)	7,190	9,385	61,934	27,371	30,258	(*q*)		336,197
1898.....	*c*3,600,000	(*q*)	4,250	(*q*)	73,573	30,766	31,153	(*q*)		491,660
1899.....	4,250,000	(*q*)	7,600	(*q*)	90,542	48,265	45,662	(*q*)		487,271
1900.....	4,850,000	(*q*)	5,250	(*q*)	80,000	48,050	39,333	(*q*)		

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Estimated. (*c*) Includes brick, building stone, lime, sands, gravels, tiles, etc. (*d*) Value of tile in 1896, $225,000, sewer pipe, $153,875; in 1897, tile, $225,000, sewer pipe, $164,250. In 1898 and 1899 sewer pipe is alone reported. (*e*) Oven coke, all the production of Nova Scotia and British Columbia. (*f*) Copper contents of ore, matte, etc., at the following values per lb.: 1896, 10$\frac{3}{16}$c.; 1897, 11$\frac{3}{16}$c.; 1898, 12$\frac{3}{16}$c.; 1899, 17·61c.; in 1900, 16·19c. (*g*) Figures for 1896 includes quartz, 9 tons, $50. (*h*) Fine kilograms calculated at $664 60 per kg. (*i*) Export returns. (*j*) Amount of pig iron produced from native ore; the total amount of pig iron smelted was 96,575 short tons, valued at $1,501,698. (*k*) Lead contents of ores, etc., at the following values per lb.: 1896, 3c.; 1897, 3·6c.; 1898, 3·78c.; 1899, 4·47c.; 1900, 4·37c. (*m*) Calculated from inspection returns at 100 gals. crude to 42 gals. refined. The value of the crude per bbl. of 35 imp. gals. was, in 1896, $1·59; in 1897, $1·42; in 1898, $1·40; in 1899, $1·48$\frac{1}{4}$, except in 1900 when the ratio 100 gal. to 54 refined, $1.62 per bbl. (*n*) Silver contents of ores, values for production and exports per oz.: 1896, $0·67; 1897, $0·598; 1898, $0·583; 1899, $0·5958; 1900, $0·6141. (*p*) In 1896, includes tripoli, 602 metric tons ($9,960); in 1897, mercury, 312 kg. ($324), also sundry minerals, estimated in part and including actinolite and tripolite; in 1898; also sundry tripolite, 922 metric tons ($16,660); in 1900, tripolite, 305 metric tons, $1,950. (*q*) Not reported. (*r*) Nickel contents of ore, matte, etc., in 1899, at 36c. per lb.; in 1900 at 47c. per lb.

MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year. (*h*)	Aluminum.		Asphalt.		Brass. (*f*)	Buhrstones. *Number.*		Cement.	Chalk.	Chloride of Lime.		Cryolite.	
1896..	*g*7	$7,537	3,843	$33,875	$477,279	1,572	$2,049	$255,029	$9,075	1,565	$58,994	21	$2,699
1897..	*g*8	5,717	342	9,012	457,342	1,499	1,827	260,842	11,826	1,361	49,368	16	2,106
1898..	(*i*)	7,102	6,006	55,164	560,014	889	1,813	376,315	14,362	1,765	55,987	17	2,315
1899..	(*i*)	9,275	8,196	95,800	747,557	1,116	1,759	480,414	14,544	1,857	50,801	50	2,120
1900..	(*i*)	12,543	2,825	68,748	853,599	1,250	1,546	520,593	12,212	1,967	65,224	18	2,721

Year. (*h*)	Clay Products.			Coal.				Coal Tar. *Barrels.*		Coke.	
	Bricks and Tiles.	Clays.	Earthenware & China.	Anthracite. (*b*)		Bituminous. (*b*)					
1896..	$193,585	$62,984	$575,493	1,428,255	$5,667,096	1,586,657	$3,352,767	18,467	$31,209	55,894	$203,826
1897..	165,073	59,386	595,822	1,322,049	5,695,168	1,595,789	3,313,826	23,661	36,942	75,596	267,540
1898..	168,012	72,795	674,874	1,325,139	5,847,685	1,735,838	3,225,151	26,702	35,194	122,527	347,040
1899..	255,237	88,517	916,727	1,583,471	6,490,509	2,220,725	3,736,663	39,296	54,447	128,172	362,826
1900..	499,128	122,965	966,254	1,500,863	6,602,912	2,512,871	4,409,313	50,484	73,874	170,471	506,839

Year. (*h*)	Copper. (*f*)	Copper Sulphate.		Emery (Wheels and Ground).	Explosives.	Flint and Stones.		Fuller's Earth.	Glass.	Gold and Silver.	
										Coin and Bullion.	Manufactures.
1896..	$294,410	710	$57,380	$18,840	$136,818	287	$3,027	$1,884	$1,104,481	$5,226,319	$340,241
1897..	270,036	516	40,469	11,231	131,562	475	5,244	1,552	1,139,764	4,676,094	296,143
1898..	867,452	738	57,497	15,478	141,731	389	5,344	3,330	1,024,706	4,390,844	297,242
1899..	798,326	726	61,749	22,343	212,968	243	2,977	3,418	1,343,058	4,705,134	342,320
1900..	1,271,270	752	87,847	44,882	247,511	280	4,342	2,661	1,658,694	8,297,438	339,145

Year. (h)	Gravel and Sand.		Iron and Steel. (f)	Kainite.		Lead. (f)	Lead Pigments and Zinc White.		Lime. *No. of Bbls.*		Litharge.	
1896..	17,193	$24,604	$10,952,607	180	$1,978	$239,109	5,312	$367,569	10,239	$7,331	481	$32,817
1897..	19,330	25,222	11,326,484	206	5,984	233,125	4,677	347,539	16,108	10,529	546	34,538
1898..	29,164	43,287	16,407,644	49	1,008	335,278	5,753	448,659	12,850	9,002	519	32,904
1899..	27,477	42,209	19,768,725	30	777	368,450	6,581	514,842	15,720	11,124	432	32,518
1900..	32,399	41,280	27,423,910	143	2,339	322,446	6,654	634,492	12,865	11,211	415	29,176

Year. (h)	Litho-graphic Stones.	Mineral Oils. *Gallons.*		Mineral Paints. (Ocher.)		Ores of Metals.		Phos-phorus.		Potassium Salts.			
										Except Saltpeter.		Saltpeter.	
1896..	$4,964	7,130,061	$628,371	158	$2,995		$24,038	10	$9,525	292	$41,037	598	$55,628
1897..	6,360	7,696,258	614,932	293	5,533	22,021	105,072	16	8,575	265	35,132	456	43,066
1898..	7,791	8,175,006	623,364	448	9,428	69,766	155,583	5	4,618	244	32,502	627	51,236
1899..	6,223	9,708,189	682,447	502	10,432	61,254	153,952	1	778	472	52,177	930	65,186
1900..	6,294	8,623,094	739,266	486	10,050	61,580	282,191	1	852	733	64,538	602	52,235

Year. (h)	Precious Stones and Jewelry.	Pumice Stone.	Quicksilver.		Sal Ammonia.		Salt.		Silex.		Slate.
1896.....	$675,420	$3,721	35	$32,343	52	$7,876	96,467	$363,438	149	$2,174	$24,176
1897.....	506,728	2,903	34	33,534	69	7,258	103,309	345,587	116	3,415	21,615
1898.....	743,607	3,829	27	36,425	38	3,721	96,935	326,202	141	2,773	24,907
1899.....	923,837	5,973	47	51,695	53	5,062	88,373	300,359	180	2,595	33,100
1900.....	732,675	5,604	39	51,987	60	6,987	92,797	325,433	182	2,876	53,707

Year. (h)	Sodium Salts, Except Chloride.		Stone and Marble. (f)	Sulphur.		Tin. (f)	Whiting.	Zinc. (f)
1896.....	12,326	$376,910	$219,298	3,145	$63,973	$1,236,640	$27,322	$127,722
1897.....	13,938	375,651	173,822	3,932	87,712	1,272,600	22,541	96,708
1898.....	16,026	446,799	189,386	17,248	373,786	1,548,346	25,761	136,849
1899.....	20,742	476,706	237,543	11,121	265,799	1,370,239	34,310	154,440
1900.....	16,748	453,733	250,034	9,584	215,433	2,415,636	34,575	167,642

MINERAL EXPORTS OF DOMESTIC PRODUCE FROM THE DOMINION OF CANADA. (a) (IN METRIC TONS AND DOLLARS.)

Year. (h)	Antimony Ore.		Asbestos.		Barytes	Clay Products.			Cement.	Cin-ders.	Coal.		Coin and Bullion.
						Brick. *Thousands.*		Clay, M'f's of.					
1896..	(i)		8,698	$482,679	$168	1,216	$7,788	$496	$1,035	$2,125	1,929,918	$3,249,069	207,532
1897..	(i)		9,951	510,916	(i)	906	5,236	796	1,332	922	999,789	3,330,017	327,298
1898..	1,118	$15,295	16,714	510,368	(i)	276	1,553	343	609	(i)	981,696	3,273,415	1,045,923
1899..	(i)		13,172	453,176	(i)	93	707	339	2,789	50	1,034,963	3,562,794	1,101,245
1900..	6	200	16,478	490,909	(i)	342	2,314	215	2,274	66	1,581,422	4,771,441	1,670,068

Year. (h)	Coke.		Copper. (c)		Explo-sives.		Fertil-izers.	Glass and Glass-ware.	Graphite.		Grind-stones.	Gypsum.		Iron and Steel, M'f's of	
												Crude.	Ground		
1896..	17	$47	1,788	$194,771	120	$92,763	$36,137	$6,881	94	$10,771	$18,853	182,217	$205,641	$23,332	$506,946
1897..	1,692	3,802	2,933	540,439	93	76,578	36,584	7,208	78	3,584	15,760	163,785	183,376	18,710	522,988
1898..	3,275	7,341	4,203	832,546	92	74,305	46,864	7,494	348	6,428	18,785	163,612	193,515	2,587	606,082
1899..	4,024	15,684	3,812	917,429	151	115,065	51,224	11,788	662	12,749	18,619	148,525	166,222	7,611	706,411
1900..	12,558	33,770	6,272	1,387,218	212	155,764	51,410	11,016	1,742	30,054	22,196	211,734	236,034	2,622	1,425,113

Year. (h)	Lime.	M'f'es of Metals Not Iron and Steel.	Mica. Crude and Cut.		Mica. Ground.	Mineral Oils. Gallons.		Nickel in Ore, Matte, etc.		Ores. Gold Quartz, etc.	Ores. Iron.		Ores. Lead. (e)	
1896..	$76,451	$31,308	251	$55,514	$113	18,241	$2,971	3,173	$486,651	$1,099,053	2,666	$39,999	9,209	$408,625
1897..	56,720	41,601	215	61,565	433	1,831	230	3,415	498,515	2,804,801	1,198	2,492	13,632	522,327
1898..	48,307	53,317	231	69,513	(i)	9,530	2,061	6,696	970,531	3,587,953	236	402	19,939	1,008,147
1899..	64,112	34,532	538	148,239	(i)	4,268	1,194	6,545	994,537	3,272,702	1,677	4,968	15,443	895,349
1900..	77,325	68,610	487	136,332	20	17,934	2,660	6,120	1,040,498	14,148,543	3,925	7,689	8,995	678,859

Year. (h)	Ores.—Continued. Manganese.		Ores.—Continued. Silver. (d)		Phosphate of Lime.		Pyrites.		Salt. Bushels.		Sand and Gravel.		Slate.		Stone and Marble.	Tin M'f's
1896..	79	$1,988	78	$1,595,548	479	$5,280	6,706	$32,893	3,007	$767	259,585	$119,847	275	$8,983	$49,679	$5,777
1897..	73	4,348	127	2,613,173	21	275	14,219	29,403	4,702	1,168	171,057	75,134	(i)		4,983	2,764
1898..	7	1,371	211	3,519,786	232	1,090	18,752	221,564	5,559	1,139	150,270	80,952	(i)		61,030	5,578
1899..	24	882	137	2,630,281	781	9,290	11,707	27,377	5,209	1,518	162,509	93,492	(i)		66,516	3,159
1900..	57	2,521	71	1,354,053	135	2,285	13,507	32,499	15,151	3,458	227,942	102,151	(i)		240,104	3,472

(a) From the tables of the *Trade and Navigation of the Dominion of Canada*. The imports figures are for home consumption only. The exports are those of domestic produce. (b) Including coal dust. (c) Represents fine copper contained in ore, matte regulus, etc. (d) Silver contents of ores. (e) Represents lead contained in ore. (f) Includes manufactures. (g) Includes alumina. (h) Fiscal years ending June 30. (i) Not reported.

MINERAL PRODUCTION OF BRITISH COLUMBIA. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Coal.		Coke.		Copper.		Gold—Kg. Lode.		Gold—Kg. Placer.		Lead. (b)		Silver—Kg.	
1896	910,562	$2,688,666	625	$3,075	1,732	$190,926	1,936	1,244,180	846	$544,026	10,977	$721,384	97,519	2,100,689
1897	896,980	2,648,562	18,116	89,155	2,415	266,258	3,301	2,122,820	798	513,520	17,618	1,390,517	170,227	3,272,836
1898	1,154,039	3,407,595	35,560	175,000	3,298	874,781	3,423	2,201,217	1,600	643,346	14,376	1,077,581	133,200	2,375,841
1899	1,314,838	3,882,396	34,799	171,255	3,503	1,351,453	4,302	2,857,573	2,092	1,344,900	9,917	878,870	91,425	1,663,708
1900	1,462,629	4,318,785	86,511	425,745	4,535	1,615,289	5,199	3,453,381	1,989	1,278,724	28,739	2,691,887	123,112	2,309,200

(a) From the *Annual Reports of the Minister of Mines*. (b) Attention should be called to the discrepancy between certain of these figures and those of the Canadian Geological Survey; practically the total production of lead in the Dominion is from British Columbian ore.

MINERAL PRODUCTION OF NOVA SCOTIA. (a) (d) (IN METRIC TONS AND DOLLARS.)

Year. (c)	Coal.	Coke.	Copper	Gold. Kg.	Grindstones.	Gypsum.		Iron Ore.	Manganese Ore.		Stone, Limestone.	Tripoli and Silica.
1896.....	2,271,140	59,681	10	813	$30,317	131,577	$122,614	57,235	131	$8,798	31,670	
1897.....	2,358,051	45,720	(b)	827	32,400	126,500	(b)	48,852	102	(b)	25,300	
1898.....	2,317,957	42,672	(b)	967	38,000	133,096		31,547	76		24,384	
1899.....	2,684,610	56,372	(b)	864	50,000	142,240		16,428	102		32,512	810
1900.....	3,290,057	62,992	(b)	945	56,500	124,237		15,755	8		50,800	998

(a) From the *Annual Reports of the Department of Mines of Nova Scotia*. (b) Not stated in the official reports. (c) For the fiscal year ending September 30. (d) There was also produced, in 1896, 178 net tons of graphite; in 1899, 400 net tons of copper ore and 335 tons barytes; in 1900, 783 net tons barytes and 600 tons copper ore.

MINERAL PRODUCTION OF ONTARIO. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Arsenic.		Clay Products. Brick, Common. Number.		Brick. Pressed.—Number. Plain.		Brick. Pressed.—Number. Fancy.		Pottery.	Tiles—Thousands. Drain.		Tiles—Thousands. Roofing.	
1896..	*Nil.*		105,000,000	$577,000	10,774,400	$88,945	1,256,600	$9,900	$104,000	13,200	$144,000	170	$6,800
1897..	*Nil.*		(g)		7,148,908	53,727	895,000	9,350	(g)	(g)		(g)	73,551
1898..	*Nil.*		170,000,000	914,000	7,754,868	87,894	(b)		155,000	22,668	225,000	(g)	
1899..	52	$4,842	233,989,000	1,313,750	10,808,000	105,000	(b)		101,000	21,027	240,246	(g)	
1900..	275	22,725	240,430,000	1,379,590	14,271,600	141,369	(b)		157,449	19,544	209,738	(g)	

Year.	Cement—*No. of Barrels.*				Copper. Metric Tons.		Gold.			Graphite.		Gypsum, Crude and Calcined. Metric Tons.	
	Natural Rock.		Portland.				Ore. Met. Tons.	Metal. Kg.	Metal. Value.				
1896.....	60,705	$44,100	77,760	$138,230	1,695	$130,660	12·059	222·5	$121,848	*Nil.*		3,810	$20,750
1897.....	84,670	76,123	96,825	170,302	2,495	200,067	(*g*)	354·9	190,244	*Nil.*		1,568	17,905
1898.....	91,528	74,222	153,348	302,096	3,798	268,080	(*g*)	505·8	275,078	272	$6,000	2,722	4,000
1899.....	139,487	117,039	222,550	444,227	2,571	176,237	(*g*)	1,164·8	419,328	1,107	16,179	1,089	16,512
1900.....	125,428	99,994	306,726	598,021	3,052	319,681	(*g*)	583·7	297,861	1,635	27,030	993	18,050

Year.	Iron.				Lime—*Bushels.*		Mica. Metric Tons.		Natural Gas.	Nickel. Metric Tons.		Petroleum.	
	Ore.		Pig.									Crude. *Imperial Gallons.* (*h*)	
1896...	(*g*)		25,675	$353,780	1,880,000	$220,000	2·2	$2,425	$276,710	1,768	$357,000	27,380,588	$1,222,307
1897...	2,507	$4,689	21,783	288,128	(*g*)		(*g*)		308,448	1,813	359,651	25,556,591	(*g*)
1898...	24,865	48,875	43,775	530,789	2,620,000	308,000	31	7,500	301,600	2,071	514,220	26,978,977	(*g*)
1899...	15,342	30,951	58,740	808,157	4,342,500	535,000	241	38,000	440,904	2,605	526,104	23,615,967	(*g*)
1900...	81,921	111,805	56,596	936,066	3,893,000	544,000	552	81,550	392,823	3,211	756,626	23,331,783	(*g*)

Year.	Petroleum.—*Continued.* Refined Products. (*h*)								(*e*) Fuel Products	Salt. Metric Tons.	
	Illuminating Oils. *Imp. Gals.*		Lubricating Oils. *Imp. Gals.*		All Other Oils. *Imp. Gals.* (*c*)		Paraffine Wax. Metric Tons.				
1896.....	11,342,880	$1,263,230	2,283,047	$204,946	7,821,262	$340,054	695·2	$76,250	$70,815	40,657	$204,910
1897.....	10,891,337	1,131,083	1,959,810	199,755	949,341	77,340	970·4	88,378	281,035	49,611	249,880
1898.....	12,281,622	1,243,490	2,043,226	202,150	1,240,967	121,840	1,186·6	116,349	286,705	53,874	278,886
1899.....	11,697,910	1,059,485	2,087,475	189,294	1,394,530	148,963	1,266·8	136,066	213,544	51,143	317,412
1900.....	11,783,755	1,076,242	1,980,428	232,805	1,463,599	174,346	2,086·4	184,718	200,934	60,408	327,477

Year.	Sewer Pipe.	Silver.		Stone. Total Value.	Terra Cotta.	Total Value. (*f*)
		Kg.	Value.			
1896....	$49,875	*Nil.*		$394,000	$24,190	$5,235,003
1897....	73,551	*Nil.*			35,800	3,899,821
1898....	93,717	2,093·5	$51,960	750,000	(*b*)	7,201,891
1899....	138,356	3,280·4	65,575	1,041,350	(*b*)	8,785,251
1900....	130,635	4,995·9	96,367	650,342	(*b*)	9,242,044

(*a*) From the *Annual Reports of the Bureau of Mines of Ontario*, Toronto. (*b*) Quantity and value included with that of plain pressed brick. (*c*) In 1897, 1898, 1899 and 1900, comprises benzine and naphtha. (*e*) In 1897, 1898, 1899 and 1900, comprises gas and fuel oils and tar. (*f*) In 1898 total includes 521 metric tons carbide of calcium ($34,445). In 1899, 5,300,000 paving brick ($42,550); 965 metric tons carbide of calcium ($74,680); 91 metric tons of talc ($500); and 1,089 metric tons of zinc ($24,000). In 1900, 454 metric tons zinc ore ($500); 3,211 tons steel ($756,626); 3,629 tons feldspar ($5,000); 907 tons talc ($5,000). (*g*) Not reported. (*h*) One barrel of crude oil is reckoned at 35 imperial gallons, and 1 barrel refined at 42 imperial gallons.

CHILE.

THERE are no official statistics of mineral production in Chile. The exports and imports are summarized in the subjoined table. With respect to the most important articles of mineral production, namely, copper and nitrate of soda, the exports practically represent the production. This is also the case with respect to iodine and borate of lime.

MINERAL EXPORTS OF CHILE. (*a*) (IN METRIC TONS AND CHILEAN DOLLARS.)

Year.	Borate of Lime.		Borax.		Clay.		Coal		Cobalt Ore.		Copper Matte.	
1895....	4,425	$221,263	107	$21,380	(*b*)		195,115	$1,560,920	13·4	$915	417	$41,673
1896....	7,486	374,294	(*b*)		40	$600	204,858	1,434,253	(*b*)		2,528	284,897
1897....	3,154	283,770	14	2,860	20	998	243,968	1,869,310	6·0	312	2,519	251,915
1898....	7,028	1,124,509	6	3,391	(*b*)		282,663	4,239,943	18·2	1,817	3,079	861,999
1899....	14,951	2,242,618	14	7,214	20	1,000	241,995	4,839,900	55·0	8,181	1,710	684,965

Year.	Copper and Silver Matte.		Copper, Silver and Gold Matte		Copper Ore.		Copper and Silver Ore.		Copper, Silver and Gold Ore—Kg.		Copper, in Bars.	
1895....	664	$134,424	15·3	$3,060	6,963	$278,515	84·4	$8,849	2,012	$402	20,042	$4,602,114
1896....	1,059	213,115	7·6	1,520	6,159	307,943	62·3	9,462	29.542	2,954	20,592	5,148,015
1897....	904	378,340	(*b*)		3,396	169,810	161·8	25,455	(*b*)		19,011	5,226,199
1898....	419	167,556	17·8	29,133	20,301	2,022,730	87·0	17,392	5,733	1,300	20,600	13,759,493
1899....	1,094	546,880	93·0	37,162	35,854	3,585,443	184·0	36,799	12,000	2,633	17,311	14,928,273

Year.	Fire Clay. Kg.		Gold Bullion. Kg.		Gold Ore.		Iodine.		Iron Ore.		Lead and Argentiferous Lead, in Bars.	
1895....	(*b*)		1,184·5	$247,749	270	$54,063	144	$1,442,580	305	$15,255	93	$4,627
1896....	(*b*)		1,061·3	849,036	367	73,475	206	2,063,950	(*b*)		594	59,415
1897....	8,200	$82	1,131·7	905,168	64	28,535	243	2,429,370	5·1	256	369	66,696
1898....	30,440	1,218	1,630·5	2,445,735	8	2,554	235	3.169,570	(*b*)		13	13,596
1899....	*Nil.*		1,625·0	2,461,284	12	6,051	304	4,108,427	(*b*)		171	34,221

Year.	Lime.		Manganese Ore.		Mineral Specimens.	Chile Saltpeter.		Silver Ore.		Silver and Gold Ore.	
1895 ...	1·2	$26	24,075	$241,383	$2,800	1,220,427	$45,528,510	2,137	$1,051,034	113	$28,255
1896....	4·0	80	26.151	261,515	700	1,111,757	43.931.667	2,750	1,257,870	666	130,182
1897....	0·8	24	23,529	1,411,648	20,300	1,057,640	37,461,559	984	434,231	260	46,631
1898....	0·7	21	20.851	447,028	1,400	1,294,227	90,675,297	284	205,386	269	57.635
1899....	1·0	42	40,931	1,227,922	64,521	1,308,718	96,650,282	302	247,597	370	129,416

Year.	Silver, in Bars, etc. Kg.		Silver, Old. Kg.		Silver-Lead Ore.		Silver Sulphuret Ore.		Tin.	
1895....	148,747	$3,867,412	375	$7,494	21	$2,050	99	$123,155	(b)	
1896....	151,226	4,183,108	988	19,754	0·8	83	160	418,785	(b)	
1897....	143,541	3,781,125	443	12,518	6·0	636	183	338,062	48	$54,613
1898....	139,756	6,987,816	55	2,219	11·8	1,557	290	434,740	8	4,900
1899....	75,899	3,791,589	(b)		32·0	4,844	339	1,017,110	8	4,979

(a) From the *Estadística Commercial de la República de Chile*, Valparaiso. It will be noticed that the values reported vary widely for the different years. This is probably to be referred to the fluctuations of the currency standard. (b) Not reported.

MINERAL IMPORTS OF CHILE. (a) (IN METRIC TONS AND CHILEAN DOLLARS.)

Year.	Bitumen for Pavements.		Brass.		Cement, Roman.		Coal.		Copper.			
									Sheets.		For Various Uses	
1894....	118	$25,600	86	$41,914	12,302	$252,314	595,639	$4,752,966	37	$20,151	31	$18,366
1895....	190	38,901	82	36,776	18,236	365,550	574,063	4,578,067	18	9,780	57	15,473
1896....	254	52,198	118	50,518	14,431	326,395	683,196	5,462,954	16	9,484	54	29,853
1897....	237	55,892	60	26,206	18,205	365,129	513,421	4,122,918	55	28,333	43	23,824
1898....	83	52,473			16,905	676,199	656,202	13,173,965	57	44,002		

Year.	Copper, Sulphate.		Earth for Smelting Furnaces.		Gold Coin.	Iron.							
						Bars and Ingots		Hoops.		Sheets, Ungalv.		Sheets, Galv.	
1894....	258	$36,275	88	$2,422	$179,595	14,397	$678,305	959	$62,012	4,113	$333,032	10,451	$1,260,622
1895....	134	18,855	177	3,980	392,900	16,506	772,723	1,198	84,794	4,714	375,848	5,972	719,721
1896....	111	16,643	69	1,386	5,635	13,970	698,611	1,452	101,605	1,256	99,985	7,917	942,449
1897....	85	10,737	100	3,542	4,440	7,604	354,592	802	63,943	1,859	153,732	10,756	1,292,176
1898....	218	65,358	30	1,785	*Nil.*	10,223	1,256,190	404	54,268	2,283	282,353	9,947	1,377,243

Year.	Lead, Bars and Sheets.		Quicksilver.		Salt.				Silver.				
					Common.		Refined.		Bars—Kg.		Coin.	Ore.	
1894....	96	$15,117	142	$144,564	5,417	$39,789	109	$8,353			$89,241	66	$15,557
1895....	194	27,750	106	106,277	3,192	23,042	246	12,116	17·3	$954,255	112,430	58	21,383
1896....	525	73,519	54	54,350	7,311	53,486	353	19,077			89,853	40	14,640
1897....	281	37,832	40	39,758	13,179	90,742	320	16,191			36,930	9	3,030
1898....	118	28,339	15	44,435	1,543	30,865	101	10,111			*Nil.*	21	5,455

Year.	Soda, Caustic.		Steel, Bars and Sheets.		Sulphur.		Tin.		Whiting and Gypsum.		Zinc.			
											Bars.		Sheets.	
1894....	1,433	$85,475	3,198	$382,223	2,291	$136,596	447	$61,936	522	$11,973	74	$9,714	352	$45,714
1895....	2,111	123,102	7,142	857,400	1,679	100,961	804	113,046	796	20,674	7	944	309	55,830
1896....	2,570	149,222	3,480	422,078	1,775	110,742	506	71,648	1,492	47,831	3	426	315	45,451
1897....	2,604	155,026	2,225	268,181	2,655	157,671	608	82,149	492	13,683	24	3,314	252	50,236
1898....	2,796	341,760	1,369	166,363	3,317	331,725	51	58,173	466	22,028	73	18,213	282	83,398

(a) From the *Estadística Commercial de la República de Chile*, Valparaiso.

CHINA.

THERE are no official statistics of mineral production in China. The exports and imports as reported by the Imperial Maritime Customs officials are summarized in the following tables:

MINERAL IMPORTS OF CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Brass Wire.		Cement.		Chinaware, Fine and Coarse.		Coal.		Colors.		Copper. Bar, Rod, Sheets, Plates, Nails.	
1894....	217·6	$50,080	9,950·5	$123,694	514·0	$70,586	494,075	$2,480,434	1,529·5	$124,010	811·7	$178,633
1895....	159·8	38,343	(*b*)	105,943	203·3	37,518	581,590	2,715,418	2,675·6	122,542	539·5	105,414
1896....	192·5	46,780	(*b*)	170,041	403·1	53,083	634,912	2,867,241	3,153·7	233,470	539·3	123,741
1897....	133·6	33,915	(*b*)	79,056	401·3	109,119	558,149	2,658,722	2,135·6	138,723	499·6	108,317
1898....	183·2	46,116	(*b*)	323,947	379·1	92,522	742,296	3,696,434	(*b*)	130,359	393·7	84,244

Year.	Copper—*Continued.* Slabs and Ore, Unmanufactured		Wire.		Wares, Unclassified.		Flint Stones.		Glass. Window—*Boxes.*		Wares.	
1894....	1,596·9	$296,917	91·8	$21,994	73·5	$21,702	1,642·3	$12,011	103,470	$194,996	$162,117	
1895....	930·3	224,237	69·9	18,915	102·4	27,930	2,261·7	17,387	80,881	165,335	185,748	
1896....	2,285·4	511,674	113·8	29,985	99·4	40,589	2,535·4	33,123	111,586	281,983	278,652	
1897....	2,525·8	606,602	79·9	20,743	34·4	13,975	2,652·9	30,707	138,553	335,532	238,784	
1898....	1,817·7	429,702	80·6	21,718	23·0	8,382	2,868·7	32,339	93,409	222,611	247,538	

Year.	Iron. Bar.		Hoop.		Nail-Rod.		Old.		Pig and Kentledge.		Sheets and Plates.	
1894....	7,565·4	$234,472	1,455·4	$52,775	20,856	$573,825	30,810	$540,846	5,453·4	$102,694	3,442·7	$157,716
1895....	8,745·9	309,540	1,401·2	48,544	16,358	480,478	25,009	419,298	7,378·5	138,497	3,664·4	184,394
1896....	9,881·5	314,737	1,949·4	81,797	26,677	761,381	52,435	946,837	8,752·3	155,880	4,861·1	229,416
1897....	6,367·9	209,284	1,480·8	54,326	11,611·4	353,935	32,881	587,278	1,458·5	36,678	3,489·6	164,302
1898....	11,309·6	352,081	1,923·3	70,683	21,253·6	643,671	43,018	798,206	10,179·2	280,540	4,709·2	215,454

Year.	Iron—*Continued.* Wire.		Wares, Unclassified	Jadestone.		Lead. Pig.		Tea and Sheet.		Machinery
1894....	2,078·1	$114,532	$123,185	152·8	$90,402	12,799	$720,873	120·5	$9,110	$862,228
1895....	2,214·3	133,506	115,700	272·0	225,497	10,858	646,253	122·3	8,199	1,908,164
1896....	2,991·3	173,474	421,083	264·2	216,728	10,114	622,690	248·1	17,328	1,672,197
1897....	2,529·1	163,455	299,645	227·5	174,467	7,709	494,721	102·2	7,271	1,956,051
1898....	2,968·0	184,461	334,550	249·5	135,311	8,832	587,558	101·2	7,500	1,231,031

Year.	Metals, Unclassed.	Nickel.		Paints.		Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.	
1894....	$253,727	38·6	$29,855	2,025	$393,839	316,674,095	$6,164,092	67·5	$59,543	570·5	$42,231
1895....	322,425	120·3	93,220	(*b*)	420,138	236,319,349	5,220,238	73·7	69,792	190·3	14,095
1896....	273,153	104·1	67,634	(*b*)	624,690	304,190,319	7,357,490	91·0	101,680	1,116·0	97,020
1897....	197,659	37·0	23,334	(*b*)	457,603	451,387,582	9,575,378	55·3	54,023	1,819·5	169,636
1898....	247,245	67·9	43,392	(*b*)	513,659	366,728,870	8,340,289	70·4	67,481	623·1	71,684

Year.	Steel.				Tin.				White Metal. (German Silver)		Yellow Metal. Bar, Rod, Sheets, and Nails.	
	Common.		Mild. or Iron Ingots.		Plates.		Slabs.					
1894....	3,575·7	$212,699	3,115·9	$95,251	1,429·0	$81,105	4,435·2	$1,495,009	172·3	$83,125	1,537·4	$243,724
1895....	2,766·0	168,062	3,573·4	118,324	3,318·0	195,276	4,590·3	1,540,592	139·7	74,793	1,569·4	236,978
1896....	5,181·9	369,762	9,758·9	220,547	1,880·7	123,901	5,516·4	1,785,541	182·1	82,953	1,719·3	305,514
1897....	3,206·9	198,455	711·4	22,223	3,543·7	209,447	4,128·9	1,396,302	241·4	122,901	1,753·6	317,137
1898....	2,908·7	183,523	9,109·9	232,763	6,775·6	393,620	3,198·5	1,131,619	230·4	116,859	1,678·4	297,903

RE-EXPORT OF FOREIGN GOODS FROM CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Cement.		Chinaware.		Coal.		Colors.		Copper, Bar, Rod Sheets, Plates and Nails.		Glass.		
											Window. *Boxes.*		Wares.
1894....	(*b*)		(*b*)		47,950	$254,031	10·8	$2,906	3·08	$298	758	$1,354	(*b*)
1895....	(*b*)		(*b*)		48,889	234,380	143·7	18,265	3·75	921	1,046	2,018	$1,394
1896....	11·6	$156	1·3	$203	42,082	271,957	31·8	7,939	(*c*) 5·20	1,528	222	580	2,252
1897....	147·0	1,935	0·1	123	47,254	233,561	33·8	8,578	5·08	1,008	1,024	2,580	1,992
1898....	122·4	2,088	0·1	81	55,238	284,501	(*b*)	5,880	(*d*) 1·93	517	1,373	3,459	2,675

Year.	Iron.								Lead—In Pigs.		Metals, Unclassed.
	Bar, Hoop, Nail-Rod, Sheets, Plates, and Wire.		Old.		Pig and Kentledge.		Wares, Unclassed.				
1894....	704·0	$29,738	170·1	$2,604	$150·6	2,878	$3,351		18·7	$1,071	$3,351
1895....	1,628·8	64,041	210·1	3,743	152·0	2,815	484		80·5	4,806	14,790
1896....	1,412·3	58,733	334·5	7,197	154·4	2,524	4,544		98·4	6,890	10,325
1897....	1,691·5	69,655	258·5	5,098	1,181·6	33,774	6,340		68·6	4,981	5,650
1898....	1,155·9	57,249	342·5	7,467	707·1	19,650	11,000		72·7	5,384	12,693

Year.	Nickel.		Paints.		Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.		Steel.	
1894....	(*b*)		34·4	$11,925	500	$8	(*b*)		(*b*)		29·3	$1,761
1895....	1·269	$1,005	(*b*)	5,506	3,262,668	72,576	8·6	$7,709	(*b*)		173·6	7,603
1896....	1·330	936	(*b*)	11,935	2,302,730	61,587	3·7	4,048	(*b*)		377·7	15,738
1897....	3·443	1,874	(*b*)	15,996	1,982,607	42,623	2·6	2,639	12·08	$1,132	591·0	20,695
1898....	4·654	2,952	(*b*)	15,016	2,585,556	59,441	4·1	4,026	(*b*)		789·6	28,179

RE-EXPORT OF FOREIGN GOODS FROM CHINA. *Concluded.*

Year.	White Metal. (German Silver)		Tin, in Slabs and Tinplates.		Yellow Metal, Bar, Rod, Sheets and Nails.	
1894....	(*b*)		344·6	$43,240	24·6	$4,261
1895....	7·1	$3,596	135·4	19,362	13·2	2,946
1896....	(*b*)		45·2	5,871	2·1	446
1897....	1·3	711	271·1	32,430	0·2	52
1898....	0·2	91	127·5	27,999	13·6	2,928

EXPORT OF NATIVE GOODS FROM CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Chinaware, Earthenware, and Pottery.		Glassware, Bangles, etc.		Gold and Silver Ware.	
1894...	18,663	$947,975	1,347·8	$304,160	2·176	$74,346
1895...	32,783	1,232,906	1,510·6	353,929	3·143	95,697
1896...	21,786	1,318,955	1,111·9	316,891	3·083	120,149
1897...	20,453	996,722	1,066·9	252,573	2·597	93,575
1898...	20,381	1,053,015	1,261·9	300,919	3·325	112,530

(*a*) From the *Returns of Trade and Trade Reports of the Imperial Maritime Customs*, Shanghai, China. In these reports the unit of quantity is chiefly the "picul," and that of value the "Haikwan-tael." In converting the original data to metric tons and dollars, the following relations were used: 1 picul = 0·060453 metric ton; in 1894, 1 Haikwan-tael = 77c. American gold; in 1895, 80c.; in 1896, 81c.; in 1897, 72c.; and in 1898, 70c., at the average sight exchange on New York, London, Paris, Berlin, Calcutta, and Hong-Kong respectively. (*b*) Not reported. (*c*) In 1896 there was also exported 111·2 metric tons of copper (unmanufactured, slabs and ore) valued at $31,966. (*d*) In 1898 there was also exported 4·41 metric tons of unclassed copperware valued at $1,821.

FRANCE.

THE official statistics of mineral production in France and her Colonies are summarized in the subjoined tables. With respect to the most important substances, reference should be made to the respective captions elsewhere in this volume.

MINERAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS; 5 f.=$1.)

Year.	Alunite.		Antimony Ore.		Asphaltum.		Barytes.		Bauxite.		Bituminous Substances. (*c*)	
1895..	330	$3,300	5,396	$68,004	*e*15,705	$138,055	2,530	$10,938	17,958	$24,282	266,660	$368,632
1896..	171	1,710	5,675	68,544	17,717	150,263	2,791	8,257	33,820	48,833	225,784	348,187
1897..	(*b*)		4,685	64,915	17,982	146,272	3,209	8,736	41,740	55,211	233,328	339,898
1898..	(*b*)		4,433	65,046	18,832	153,758	2,763	7,338	36,723	67,133	229,108	333,888
1899..	(*b*)		7,392	140,093	(*b*)		4,058	11,524	48,215	83,987	258,449	360,657

Year.	Cement.		Clay Products.				Coal.					
			Potters' Clay.		Refractory Clay.		Coal.		Lignite.		Peat.	
1895..	838,739	$3,995,733	182,357	$237,734	533,819	$237,734	27,582,819	$60,930,220	437,074	$779,554	131,547	$366,439
1896..	934,624	4,556,503	246,677	233,340	291,690	311,614	28,750,452	62,516,853	439,448	776,938	130,207	379,047
1897..	976,813	4,716,471	270,292	243,200	318,185	333,428	30,337,207	66,020,171	460,422	781,517	98,067	253,851
1898..	1,072,025	5,359,620	260,362	203,344	295,913	348,532	31,826,127	71,701,384	529,977	929,300	104,265	301,486
1899..	1,144,271	5,733,404	310,220	272,176	367,432	375,891	32,256,148	80,412,932	606,564	1,096,181	99,230	302,637

Year.	Copper Ore.		Fluorspar.		Gyspum.				Iron Ore.		Lead-Silver Ore.	
					Crude.		Calcined.					
1895..	(*b*)		2,200	$6,600	85,885	$129,771	1,888,236	$3,386,051	3,679,767	$2,341,711	21,503	$448,835
1896..	106	$704	1,940	6,068	264,187	241,608	1,429,550	2,516,112	4,069,390	2,565,205	19,042	450,709
1897..	956	3,645	2,722	8,160	292,753	264,845	1,369,269	2,458,337	4,582,236	3,008,028	21,212	556,261
1898..	382	2,841	3,077	9,231	303,531	281,690	1,449,384	2,596,870	4,731,394	3,207,447	23,342	640,226
1899..	2,021	64,416	5,140	15,888	263,879	261,192	1,372,067	2,475,616	4,985,702	3,640,115	17,505	543,146

Year.	Lime.		Manganese Ore.		Millstones.		Mineral Paints. (Ochers.)		Petroleum, Crude.		Phosphate Rock.	
1895..	1,821,215	$4,954,114	30,871	$184,143	33,396	$233,762	33,082	$147,938	9,446	$215,002	526,784	$3,360,599
1896..	2,224,847	5,569,917	31,318	185,717	28,237	224,347	27,499	129,704	9,292	209,184	582,667	3,502,028
1897..	2,201,428	5,682,323	37,212	208,035	32,175	244,083	32,299	156,180	10,233	234,811	535,390	2,854,887
1898..	2,339,850	5,975,874	31,935	166,211	*k*38,929	727,235	33,780	158,014	9,694	221,172	568,558	3,115,958
1899..	2,343,377	6,081,922	39,897	223,337	41,535	765,242	32,750	161,473	(*b*)		645,868	3,334,145

Year.	Pyrites.		Salt.		Slate.				Stone.	
					Roofing.		Slabs.		Building.	
1895..	253,416	$639,414	871,312	$2,406,155	291,444	$3,191,646	2,103	$32,364	10,142,933	$7,076,258
1896..	282,064	712,986	1,042,614	2,473,568	283,352	3,154,551	1,148	31,006	10,089,845	9,084,571
1897..	303,488	752,658	948,003	2,239,824	310,820	3,620,949	1,143	31,282	10,105,438	9,355,103
1898..	310,972	785,242	999,283	2,115,120	316,911	4,118,789	1,318	38,552	9,989,416	9,890,737
1899..	318,832	827,623	1,193,532	2,506,832	299,307	3,615,362	1,162	36,003	10,587,789	10,445,644

Year.	Stone.—*Continued.* Limestone. (Flux.)		Marble.		Paving Blocks.		Sulphur Ore. (*d*)		Zinc Ore.	
1895....	900,422	$243,287	39,599	$415,419	812,342	$2,863,232	4,213	$14,077	72,989	$873,765
1896....	721,296	211,511	119,168	907,257	677,213	2,157,963	9,720	25,660	81,346	1,160,021
1897....	709,562	198,777	118,675	927,134	568,677	1,918,105	10,723	31,252	83,044	1,305,003
1898....	695,501	200,660	124,161	993,831	568,483	1,898,678	9,818	27.141	85,550	1,475,581
1899....	924,945	246,645	191,030	1,406,773	621,799	2,107,324	11,744	28,884	84,813	1,915,402

METALLURGICAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS; 5 f.=$1.)

Year.	Aluminum.		Antimony.		Copper.		Gold—Kg.		Iron and Steel. Iron, Pig.		Iron and Steel. Iron, Wrought.	
1895....	360	$360,000	779	$98,734	8,245	$1,872,740	380	$261,744	2,003,868	$22,264,312	756,793	$23,443,660
1896....	370	259,000	969	130,217	6,544	1,641,876	327	225,637	2,339,537	26,476,584	828,758	25,343,590
1897....	470	285,500	1,033	141,857	7,376	1,845,243	276	190,109	2,484,191	29,121,027	584,540	24.406,664
1898....	565	301,800	1,226	163,200	7,834	2,270,200	267	183,900	2,525,100	31,858,400	766,000	25.221,800
1899....	763	401,500	1,499	243,800	6,640	2,419,060	270	186,000	2,578,400	37,342,000	834,000	30,765,400

Year.	Iron and Steel—*Con.* Steel. (*l*)		Lead. (*f*)		Nickel.		Silver—Kg.		Zinc.	
1895.....	714,523	$36.645,671	7,627	$385,422	1,545	$1,087,500	71,073	$1,563,606	24,230	$1,781,515
1896.....	916,817	41,898,067	8,232	444,371	1,545	921,500	70,479	1,592,825	35,585	2,922,628
1897.....	994,891	45,276,658	9,916	630,928	1,245	741,500	80,351	1,639,160	38,067	3,263,490
1898.....	1,174,000	55,042,800	10,920	738,400	1,540	920,000	90.583	1,817,000	37,155	3,598,600
1899.....	1,240,000	64,877,400	15,981	1,343,500	1,740	1,040,000	82,105	1,642,100	39,274	4,508,400

(*a*) From *Statistique de l'Industrié Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist, bituminous sand, and asphaltic limestone. (*d*) Sulphur and limestone impregnated with sulphur. (*e*) Including briquettes. (*f*) Lead produced from native ores only, and does not include the metal produced from foreign ores and bullion. (*k*) Finished product. (*l*) Wrought steel.

MINERAL IMPORTS OF FRANCE. (*a*) (IN METRIC TONS; 5 f.=$1.)

Year.	Bituminous Substances. (*b*)		Coal. (*c*)		Copper.		Gold.	Silver.	Iron and Steel.		Iron, Cast. (Crude.)	
1896..	30,954	$495,200	10,180,449	$34,733,600	46,830	$12,692,400	$60,167,745	$45,951,627	48,423	$1,712,000	18,323	$368,800
1897..	29,931	419,000	10,457,255	37,894,400	54,460	14,375,400	58,143,077	42,468,708	60,804	1,954,800	35,633	944,400
1898..	20,385	244,600	10,445,090	41.438,200	52,976	14,998,000	39,881,575	38,274,504	47,325	1,941,800		998,000
1899..	30,770	369,200	11,896,030	51,646,600	58,419	20,450,000	63,697,020	37,528,657	64,178	3,283,400		2,182,200
1900..		511,200		63,045,200		21,628,800	90,408,723	29,164,546		5,815,600		3,151,400

Year.	Lead.		Nickel.		Sodium Nitrate	Stone.	Sulphur.		Tin.		Zinc.	
1896..	79,752	$5,751,600	425	$374,800	$9,025,400	$2,440,000	111,515	$1,965,400	8,400	$2,820,400	33,459	$3,060,800
1897..	86,589	6,661,800	316	475,400	8,105,400	2,675,800	136,118	2,602,200	7,642	2,572,000	31,211	2,998,800
1898..	74,902	5,843,600	330	525,000	8,026,400	2,814,600	130,289	2,800,400	9,247	3,475,800	32,342	3,682,400
1899..	67,149	6,657,400	286	399,600	9,341,600	4,494,800	120,062	2,813,000	6,907	4,495.400	25,516	3,467,600
1900..		7,106,400		397,740		5,144,400		3,140,200		4,758,200		4,470,200

Year.	Alum.	Antimony Ore.	Borax.	Bromides.	Cement	Chromate of Potash and of Soda.	Copper Ore.	Gold Ore. Kg.	Hydrochloric Acid.	Iron. Ore.	Iron. Pyrites.
1895.....	109		442	12	13,441	2.875	10,450	*b*8,811	2,777	1,651,369	67,930
1896.....	41		255	13	14,395	2,838	8,584	*c*101,499	2.468	1,862,043	45.788
1897.....	54	(*d*)	264	18	15,141	2,852	11,960	(*d*)	2,119	2,137,860	69.470
1898.....	27	(*d*)	139	30	11.290	2,890	8,779	(*d*)	1,994	2,032.240	71.569
1899.....	34	(*d*)	123	46	13,640	3,147	8,517	(*d*)	1,905	1,950,665	109,696

Year.	Kaolin.	Lead Ore.	Lead Carbonate	Lime, Chloride.	Lime.	Manganese Ore.	Mercury	Nitrate of Potash.	Nickel Ore.	Nitric Acid.
1895.....	359	5,032	1,077	1,047	246,677	414	178	775	10,303	702
1896.....	38,703	5,569	892	2,033	283,707	616	234	2,614	15,756	684
1897.....	42,384	13,981	1,327	1,713	321,647	855	248	1,309	17,441	774
1898.....	40,352	14,377	1,376	1,288	346,000	1,002	221	1,008	24,935	922
1899.....	36,904	12,570	2,029	1,887	321,610	1,066	276	1,015	28,620	1,232

Year.	Oxides.						Petroleum.	Phosphates.	Plaster.	Platinum. Kg.	Potash and Carbonate of.	Potassium Chloride.
	Cobalt	Copper.	Iron.	Lead.	Uranium.	Zinc.						
1895.....	5	24	855	1,931	2	802	258,700	139,600	2,412	926	796	3,524
1896.....	5	22	897	1,984	4	938	272,693	256,888	1,774	2,117	1,526	11,499
1897.....	9	29	1,125	1,759	5	1,114	288,671	313,608	1,869	1,069	1,769	11,630
1898.....	9	52	1,021	1,874	15	1,256	291,961	336,842	2,040	505	2,418	10,929
1899.....	9	36	1,037	1,807	44	1,765	306,078	242,021	2,260	817	2,779	13,335

Year.	Sal Ammoniac.	Salt.	Silver Ore. Kg.	Soda, Caustic	Sulphates.		Sulphide of Mercury.	Sulphuric Acid.	Superphosphate of Lime.	Tin Ore.	Zinc Ore.
					Copper.	Iron.					
1895.....	9,923	17,528	*f*524,394	1,021	24,404	3,882	23	3,461	150,758	104	41,622
1896.....	15,256	17,191	*f*1,818,650	1,109	33,803	3,086	25	3,995	185,602	7	50,899
1897.....	27,454	32,917	(*d*)	1,378	30,132	1,353	24	3,147	195,853	149	58,074
1898.....	20,426	35,863	(*d*)	1,772	30,897	896	19	4,666	178,569	357	60,481
1899.....	12,210	37,970	(*d*)	1,494	21,733	1,698	21	4,583	171,631	486	78,192

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*a*) (IN METRIC TONS.)

Year.	Aluminum.	Antimony.		Cement	Coal.	Copper.		Gold. Kg. (*e*)	Iron.				Iron Pyrites
		Ore.	Metal			Ore.	Metal		Ore.	Pig.	Bars.	Steel.	
1896 .	793	736	73·8	242,247	1,044,820	1,261	10,494	2,193	238,430	195,212	24,721	44,795	44,232
1897....	224	623	61·4	244,504	1,142,195	2,000	12,667	3,335	299,589	108,645	39,894	45,809	54,367
1898....	192	616	100·6	241,150	1,320,616	1,783	14,350	1,812	236,169	162,991	27,424	47,278	60,406
1899....	256	304	254·7	244,480	1,229,090	2,078	17,949	2,622	291,346	153,792	29,112	33,584	53,395
1900....	324	153	336·2	231,450	1,201,210	9,197	16,791	883	371,799	114,361	18,763	19,535	61,530

Year.	Lead.		Manganese Ore.	Millstones and Pieces. *Number.*	Nickel. Refined	Phosphate Rock.	Plaster.	Silver. Kg. (*f*)	Tin.	Zinc.	
	Ore.	Metal.								Ore.	Metal.
1896....	8,597	10,856	10,913	196,685	490	48,719	89,952	9,849	744	62,415	10,485
1897....	12,007	10,364	19,464	158,979	498	69,188	107,823	5,374	651	79,909	10,977
1898....	10,216	3,663	12,229	203,584	526	93,742	106,790	1,886	587	60,664	16,995
1899....	3,909	1,163	12,289	112,620	280	70,517	112,520		666	76,104	14,958
1900 ...	2,345	958	8,392	65,561	598	89,135	231,450	15,470	716	54,665	12,712

(*a*) The figures are from *L'Economiste Français*, and represent the *Commerce Spécial* of France. (*b*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*c*) Including coke. (*d*) Not reported. (*e*) Gold and platinum, in ore, sheets, leaves, or threads. (*f*) Silver in ore, sheets, leaves, or threads.

MINERAL PRODUCTION OF ALGERIA. (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Antimony Ore.		Cement.		Clays.		Copper Matte.		Gypsum, Crude.		Gypsum, (Plaster).		Iron.	
													Ore.	
1895..	307	7,365	...				364	$30,800	2,800	$1,248	34,136	$131,978	318,416	$503,946
1896..	658	18,957	60	$300	48,297	$42,526	427	39,028	300	138	29,870	114,123	374,476	583,946
1897..	781	21,621	...		67,180	59,607	289	28,380	350	175	29,120	109,473	441,467	663,282
1898..	138	4,416	...		78,690	60,275	488	54,200	150	75	29,750	110,585	473,569	703,667
1899..	200	10,400	...		88,600	73,874	472	43,700	200	100	31,800	117,795	550,921	932,326

Year.	Iron—*Con.* Cast, 2d Fusion.		Lead-Silver Ore.		Lime. Hydraulic.		Lime. White.		Marble.		Onyx.	
1895	537	$35,894	178	$2,959	20,000	$120,000	11,890	$39,840	1,112	$32,248	1,764	$132,300
1896	577	35,430	117	2,188	20,000	120,000	9,450	36,480	900	26,100	900	25,530
1897	699	44,870	145	3,041	20,425	122,500	9,215	32,260	1,660	26,150	364	25,480
1898	*Nil.*		120	3,120	13,000	78,000	12,975	46,783	985	30,004	219	12,483
1899	*Nil.*		389	10,482	12,000	72,000	13,645	48,981	225	428	217	12,397

Year.	Phosphate Rock.		Quicksilver Ore.		Salt.		Sand and Gravel.		Zinc Ore.	
1895	157,886	$634,323	85	$6,210	25,758	$102,990	20,400	$2,400	13,967	$93,486
1896	165,738	500,905	8	500	19,658	85,122	41,400	8,280	17,587	168,768
1897	228,141	912,564			23,222	78,058	80,860	20,280	32,269	301,538
1898	269,500	1,078,000			21,300	86,000	72,185	17,717	29,800	281,400
1899	324,983	1,299,932			17,378	67,300	72,760	15,827	42,970	562,579

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*) (IN METRIC TONS.)

Substances.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Chrome iron ore	4,343	512	242	2,927	8,079	20,186	3,949	7,712	12,634
Cobalt ore	1,343	2,200	2,200	4,112	4,277	*c*4,823	3,200	2,373	3,294
Copper ore	199	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	2,200	*Nil.*	6,349
Copper regulus	152	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)		(*b*)	(*b*)
Lead ore	236	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	200	(*b*)	(*b*)
Nickel ore	60,921	83,114	69,614	61,243	29,623	6,417	26,464	74,614	103,908

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not stated in the reports. (*c*) Exports.

MINERAL PRODUCTION OF TUNIS. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Salt.		Lead Ore.		Zinc Ore.	
1895	8,000	$7,200	(*b*)		14,800	*c*$112,600
1896	5,500	22,000	(*b*)		12,100	118,600
1897	8,100	32,400	2,123	$26,960	11,830	147,200
1898	7,300	33,200	2,375	37,680	21,477	185,520
1899	8,850	35,400	2,263	53,400	20,079	313,400

(*a*) From *Annual General Reports*, by C. Le Neve Foster, and *Statisque de l'Industrie Minérale.* Additional products in 1896: Gypsum, 4,700 metric tons; marble, 1,000 metric tons; phosphate of lime, 1,000 metric tons; building stone (dressed), 18,000 cu. meters; stone (broken), 135,000 cu. meters. In 1900, 70,000 tons phosphate rock, valued at $168,000; 1,050 tons lead ore, valued at $18,900. (*b*) Not reported. (*c*) Value corresponding to only 10,800 tons.

GERMANY.

THE mineral statistics of the German Empire, together with those of Baden, Bavaria, Prussia and Saxony, are summarized in the subjoined tables:

MINERAL PRODUCTION OF GERMANY. (*a*) (*b*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alum.		Aluminum Sulphate.		Antimony and Manganese.		Antimony Ore.		Arsenic Ore.		Arsenical Products.	
1896.....	3,430	$88,250	34,370	$595,000	1,326	$156,111	*Nil.*		3,691	$46,960	2,637	$221,397
1897.....	2,995	73,838	37,053	613,684	1,665	210,744	*Nil.*		3,777	56,021	2,989	270,949
1898.....	4,069	91,086	35,366	514,952	2,711	302,892	*Nil.*		3,540	52,414	2,679	253,623
1899.....	3,358	73,500	37,693	568,250	3,149	434,000	*Nil.*		3,834	61,250	2,423	267,250
1900.....	(*e*)		(*e*)		(*e*)		*Nil.*		4,380	79,000	(*e*)	

Year.	Asphaltum.		Boracite.		Cadmium—Kg.		Coal.		Cobalt, Nickel and Bismuth Ores.		Copper, Ingot.	
1896....	61,552	$113,348	184	10,620	10,000	$19,117	85,690,233	$148,244,000	4,087	$129,688	29,319	$7,293,387
1897....	61,645	94,634	198	10,222	15,531	44,157	91,054,982	162,234,685	3,355	139,777	29,408	7,545,376
1898....	67,649	104,084	230	10,746	14,943	31,162	96,279,992	177,564,243	3,157	138,545	30,695	8,182,102
1899....	74,770	130,250	183	8,750	13,608	21,250	101,639,753	197,362,000	1,270	133,500	34,633	12,519,000
1900....	89,685	160,000	232	11,000	(*e*)		109,271,726	241,498,250	4,495	168,000	(*e*)	

Year.	Copper Matte and Black Copper.		Copper Ore.		Gold—Kg.		Graphite.		Iron Ore.	
1896.....	598	$39,083	717,306	$4,239,362	2,487	$1,728,938	5,248	$72,108	14,162,315	$12,349,650
1897.....	315	14,380	700,619	4,752,552	2,781	1,934,371	3,861	66,126	15,465,979	15,021,922
1898.....	62	2,170	702,781	4,921,152	2,847	1,978,353	4,593	97,916	15,893,246	15,202,159
1899.....	95	4,000	733,619	5,217,000	2,605	1,814,750	5,196	120,250	17,989,635	17,542,500
1900.....	(*e*)		747,775	5,956,000	(*e*)		9,248	136,500	18,964,367	19,407,000

Year.	Iron, Pig.		Lead.		Lead Ore.		Lignite.		Litharge.		Magnesium Sulphate.(*f*)	
1896..	6,295,272	$73,930,749	113,792	$6,258,097	157,504	$3,249,000	26,797,880	$15,233,273	3,930	$235,698	2,350	$5,250
1897..	6,864,405	87,345,441	118,881	7,160,138	150,179	3,253,884	29,419,503	16,562,642	3,341	213,699	2,601	5,637
1898..	7,215,927	93,575,641	132,742	8,555,606	151,601	3,412,128	31,648,498	18,339,869	3,857	265,496	2,444	5,277
1899..	7,160,203	102,820,750	129,225	9,315,000	144,370	3,528,000	34,204,666	17,458,970	3,561	270,750	2,032	4,250
1900..	(*e*)		(*e*)		148,230	4,516,000	40,279,332	24,436,500	(*e*)		1,750	3,750

Year.	Manganese Ore		Magnesium Chloride (From Solution.)		Magnesium Sulphate (From Solution.)		Mineral Paints.		Nickel & Various By-Products. (*c*)		Petroleum.	
1896....	45,062	$120,155	17,525	$57,386	27,161	$107,835	2,668	$75,313	1,391	$1,365,330	20,395	$297,128
1897....	46,427	115,356	18,014	64,294	35,072	155,585	3,119	84,071	1,464	1,492,337	23,303	349,111
1898....	43,354	111,786	19,919	96,973	30,295	122,667	3,031	91,153	1,691	1,465,254	25,789	394,552
1899....	61,329	177,750	21,369	81,250	39,540	148,500	3,351	97,000	1,747	1,556,000	27,027	394,500
1900....	59,203	183,500	(*e*)		(*e*)		(*e*)		(*e*)		50,375	931,500

Year.	Potassium Salts.									
	Chloride.		Kainite.		Potassium and Magnesium Sulphate.		Sulphate.		Unspecified.	
1896....	174.515	$5,718,559	856,290	$2,989,736	4,623	$85,977	19,682	$813,381	902,707	$2,964,750
1897....	168,001	5,764,423	992,389	3,486,007	7,812	149,079	13,774	565,720	953,798	3,030,143
1898....	191.347	6,380,220	1,103,643	3,835,856	13,982	259,485	18.853	763,397	1,105,212	3,576,628
1899....	207,506	6,801,250	1,108,159	3,838,250	9,765	195,000	26,103	1,027,500	1,384,972	4,202.000
1900....	(*e*)		1,178,527	4,134,000	(*e*)		(*e*)		1,874,346	5,643,750

Year.	Pyrites.		Salt.		Salt, Rock.		Silver and Gold Ore.		Silver—Kg.	
1896....	124,950	$231,579	547,486	$3,661,034	755,833	$755,888	18,487	$596,604	428,429	$9,718,000
1897....	133,302	241,117	543,272	3,034,128	763,412	804,298	9,708	363,271	448,068	9,095,366
1898....	136,849	242,586	565,683	3,116,087	804,658	838,656	12,413	336,657	480,578	9,539,162
1899....	144,623	259,250	571,058	3,021,750	861,123	957,000	13,506	479,750	467,590	9,458,000
1900....	169,447	303,750	(e)		927,784	1,057,750	12,537	514,500	(e)	

Year.	Sodium Salts. (Glauber Salt.)		Sulphur.		Sulphuric Acid.		Sulphates. (d)							
							Copper.		Iron.		Zinc.		Copper and Iron Mixed.	
1896....	71,958	$448,915	2,263	$47,181	590,888	$3,781,092	6,046	$466,478	9,788	$39,072	4,811	$67,171	165	$6,218
1897....	68,822	434,198	2,317	48,357	623,130	3,739,472	5,549	470,016	10,351	44,684	5,488	77,495	266	10,543
1898....	69,111	452,509	1,954	43,167	664,865	4,085,734	4,352	356,540	10,422	42,707	6,104	91,152	176	6,991
1899....	79,062	504,000	1,663	36,000	832,666	5,737,000	5,142	460,750	10,931	38,750	7,117	107,000	212	9,000
1900....	(e)		(e)		(e)		(e)		(e)		(e)		(e)	

Year.	Tin.		Tin Ore.		Uranium and Wolfram Ores.		Zinc.		Zinc Ore.		Vitriol and Alum Ores. Unspecified.	
1896....	826	$135,734	88	$5,881	41	$7,081	153,100	$11,777,005	729,942	$4,255,473	369	$512
1897....	929	287,829	55	5,982	38	8,367	150,739	12,619,131	663,850	4,220,339	225	338
1898....	993	372,252	51	3,550	50	11,527	154,181	14,708,459	641,706	5,511,819	188	282
1899....	1,481	870,750	72	10,000	50	13,000	153,155	18,737,750	664,536	8,855,000	533	750
1900....	(e)		81	11,250	43	11,250	(e)		639,215	6,488,250	350	500

(a) Including Luxemburg. (b) From *Vierteljahrs- und Monats-hefte zur Statistik des Deutschen Reichs.* (c) Including metallic bismuth, cobalt products, and uranium salts. (d) There was also produced nickel sulphate and tin chloride as follows: 1896, 176 tons, $42,986; 1897, 209 tons, $51,333. (e) Statistics not available at time of publication. (f) Kieserite, glauberite, etc.

MINERAL IMPORTS OF GERMANY. (a) (IN METRIC TONS; unit of value, $1,000; $1 = 4 marks.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products.					
									Brick and Roofing Tile.		Porcelain.		Kaolin, Feldspar and Fire clay.	
1895..	23,785	$725	299	$300	29,203	$1,600	27,351	$200	114,020	$375	748	$200	153,911	$1,350
1896..	26,655	800	335	350	32,061	1,450	32,394	275	140,333	475	806	325	192,807	1,675
1897..	29,633	900	417	425	33,113	1,325	42,364	350	151,455	575	812	350	207,155	2,050
1898..	(f)		459	475	30,254	1,275	53,519	325	c186,183	600	788	325	208,186	2,100
1899..	(f)		495	550	28,868	1,450	63,388	300	c176,704	675	704	300	235,233	2,500

Year.	Coal.		Coal. (Lignite.)		Coke.		Copper.			
							Bars and Sheets.		Crude. (d)	
1895.....	5,117,356	$15,825	7,181,050	$9,875	461,779	$1,675	426	$125	44,365	$10,050
1896.....	5,476,753	15,275	7,637,503	11,275	393,881	1,625	401	125	56,115	13,675
1897.....	6,072,029	16,625	8,111,076	12,775	435,161	1,950	400	125	67,573	17,025
1898.....	5,820,332	17,250	8,450,149	13,950	332,579	1,675	450	150	73,291	19,700
1899.....	6,220,489	21,350	8,616,751	15,075	462,577	2,600	610	250	70,091	26,000

Year.	Copper—*Con.*		Copper and Brass Manufactures.						Glass Manufactures, All Kinds.		Gold.			
	Scrap and Coin.		Fine.		Wire.		Cartridge Cases, Coarse Wares, etc.				Bullion. Kg.		Coin. Kg.	
1895.....	1,703	$350	625	$525	171	$50	563	$250	3,119	$1,100	17,075	$11,875	19,949	$12,475
1896.....	3,170	700	797	675	127	50	582	275	2,823	1,050	45,417	31,600	37,507	23,475
1897.....	4,199	950	846	700	80	25	612	300	2,057	475	34,991	24,325	22,914	14,350
1898.....	4,720	1,150	881	800	55	25	546	275	2,408	525	62,937	43,775	60,355	37,750
1899.....	4,992	1,750	962	925	79	25	565	350	2,334	525	51,539	35,950	50,769	31,875

Year.	Gold and Silver. Scrap, Pagament. Kg.		Gold and Silver. Manufactures. Kg.		Gold, Silver, and Platinum Ores.		Graphite.		Iodine.		Iron. Angle.		Iron. Blooms, Bars, and Ingots.		Iron. Castings.	
1895..	45,174	$4,125	35,094	$975	6,134	$1,350	12,565	$425	113	$750	124	(f)	757	$25	13,749	$1,675
1896..	39,395	3,700	34,310	825	6,024	3,950	13,718	450	94	625	176	(f)	1,054	25	19,600	2,450
1897..	36,664	3,075	35,160	750	8,927	4,475	17,366	600	164	950	1,081	$25	1,038	25	24,627	2,950
1898..	54,793	4,525	31,549	700	7,481	2,650	20,269	950	216	1,275	207	(f)	1,553	50	39,371	3,825
1899..	44,463	3,725	34,775	875	7,597	2,725	23,400	1,075	191	1,125	898	25	(f)		45,853	4,925

Year.	Iron.—*Continued.* Ore.		Pig.		Rails.		Scrap.		Wire.		Wrought, in Bars.	All Other Manufactures.		Lead, Pig and Scrap.		
1895..	2,617,136	$6,825	188,217	$2,250	1,831	$25	11,339	$125	5,583	$450	19,777	$700	11,654	$1,225	28,449	$1,500
1896..	2,586,706	8,700	322,502	4,000	140	(f)	14,679	175	6,398	450	23,770	875	12,933	1,650	33,016	1,925
1897..	3,185,644	11,675	423,127	5,375	774	25	37,957	450	5,609	375	29,467	1,225	18,135	1,975	35,092	2,350
1898..	3,516,577	13,625	384,561	4,900	267	(f)	23,328	300	7,166	475	26,014	1,100	20,158	1,900	47,497	3,250
1899..	4,165,372	17,550	612,652	9,975	1,319	50	63,141	1,050	8,582	675	37,179	1,800	32,532	2,900	55,635	4,550

Year.	Lead and Copper Ores.		Lead, White.		Manganese Ore.		Nickel.		Oxide. (Potash.)		Petroleum. Illuminating Oil.		Petroleum. Lubricating Oil.	
1895..	65,270	$2,825	479	$25	22,576	$275	*b* 621	$425	1,634	$125	811,058	$15,400	75,041	$3,275
1896..	88,341	2,025	579	50	33,870	750	951	600	1,430	100	853,642	14,950	81,256	3,425
1897..	90,114	3,300	696	50	86,911	925	1,390	875	1,734	125	946,344	12,300	83,957	3,250
1898..	64,727	2,800	822	75	130,711	1,325	1,467	850	1,486	100	954,646	16,200	97,028	3,750
1899..	65,821	3,675	703	75	196,825	2,275	1,891	825	1,737	125	963,943	19,775	106,624	4,400

Year.	Phosphate Rock.		Potassium Salts. Chloride.		Potassium Salts. Cyanide.		Potassium Salts. Iodide.		Potassium Salts. Nitrate.		Potassium Salts. Sulphate.		Pyrites. (*e*)	
1895..	278,046	$3,475	1,334	$50	5	(f)	22	$125	1,005	$100	895	$25	293,446	$1,450
1896..	216,950	2,700	1,058	50	3	(f)	29	150	1,380	125	703	25	343,852	1,650
1897..	289,234	3,625	715	25	7	(f)	18	25	2,889	275	912	25	356,869	1,900
1898..	270,988	2,700	422	25	2	(f)	16	50	1,895	175	999	25	376,817	2,175
1899..	407,457	4,325	443	25	3	(f)	9	25	1,785	175	533	25	437,732	3,750

Year.	Salt.		Silica, Sand, Marl, etc.		Silver. Bullion—Kg.		Silver. Coin—Kg.		Slag and Slag Wool.		Slag, Thomas Slag, Ground.		Slate.	
1895..	24,286	$100	214,537	$225	97,824	$2,150	17,764	$350	537,542	$1,825	92,251	$550	52,418	$950
1896..	22,908	100	253,905	250	127,753	2,900	20,785	425	680,251	2,525	83,765	525	53,583	1,050
1897..	(f)		228,241	225	147,034	2,975	20,331	375	670,224	2,575	110,216	575	48,380	1,075
1898..	(f)		239,708	250	104,770	2,075	40,132	725	685,118	2,625	88,374	500	57,571	1,400
1899..	(f)		279,089	275	89,930	1,825	(f)		892,764	3,950	68,305	475	63,309	1,550

Year.	Soda, Calcined.		Soda. Nitrate. (Chile Saltpeter.)		Stassfurt Salts.		Stone. Rough or Simply Hewn.		Stone. Limestone, Lime.		Stone. Grindstones, Polishing and Whetstones.		Sulphur.	
1895..	1,008	$25	459,514	$17,800	910	$50	760,433	$3,800	221,685	$1,100	2,734	$350	18,836	$375
1896..	1,295	25	449,028	16,850	143	(f)	767,908	3,850	216,641	1,200	2,869	275	21,864	500
1897..	916	25	465,493	16,875	6	(f)	853,825	4,275	235,715	1,300	(f)		25,305	625
1898..	524	(f)	425,054	15,325	17	(f)	931,826	4,275	242,397	1,325	(f)		30,269	750
1899..	515	(f)	526,944	19,425	132	(f)	1,021,755	5,200	(f)		(f)		(f)	

Year.	Tin. Crude.		Tin. Manufactures		Zinc. Crude.		Zinc. Drawn and Rolled.		Zinc. Manufactures		Zinc. Ore.		Zinc-White, Zinc-Gray, and Lithophone.	
1895..	10,581	$3,375	79	$75	17,542	$1,250	128		114	$75	25,818	$300	2,906	$225
1896..	13,798	4,275	75	75	16,343	1,350	180	$25	139	75	21,493	325	2,899	250
1897..	12,395	3,875	75	75	19,734	1,850	130	25	146	75	24,735	400	3,532	325
1898..	14,623	5,300	82	100	24,116	2,425	53	(f)	128	75	48,050	900	3,653	375
1899..	12,253	7,575	83	125	23,691	2,925	95	25	126	75	57,880	1,450	4,226	475

MINERAL EXPORTS OF GERMANY. (*a*) (IN METRIC TONS; unit of value, $1,000; $1 = 4 marks.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products. Roofing Tile, and Building Stone.		Clay Products. Porcelain.		Kaolin, Feldspar and Fire clay.	
1895	1,645	$75	1,669	$1,675	1,336	$75	471,124	$3,000	188,046	$1,350	19,441	$4,550	111,277	$1,125
1896	2,174	100	1,977	2,050	2,201	100	478,340	4,100	287,811	1,775	21,624	8,975	125,674	1,250
1897	2,727	75	1,899	1,950	2,623	100	524,557	4,500	233,229	1,550	21,687	8,775	121,535	475
1898	(*f*)		2,045	2,150	4,083	175	551,744	5,000	*c*265,110	1,000	21,644	8,425	129,082	650
1899	(*f*)		2,312	2,575	1,553	75	580,255	5,175	*c*224,819	850	23,110	9,275	143,406	725

Year.	Coal.		Coal, Lignite.		Coke.		Copper. Crude. (*d*)		Copper. Bars and Sheets, Unplated.		Copper. Scrap and Coin.	
1895.....	10,360,838	$26,750	18,814	$25	2,293,328	$8,900	6,329	$1,425	4,700	$1,300	2,136	$450
1896.....	11,598,757	30,475	15,703	25	2,216,395	9,000	5,996	1,500	5,406	1,700	2,968	650
1897.....	12,389,907	33,375	19,112	25	2,161,886	9,150	7,183	1,825	5,718	1,825	2,164	525
1898.....	13,989,223	39,925	22,155	25	2,133,179	10,200	6,972	1,875	5,369	1,800	3,636	900
1899.....	13,943,174	45,050	20,925	25	2,137,985	11,500	7,061	2,600	4,871	2,125	5,217	1,800

Year.	Copper and Brass Manufactures. Fine.		Copper and Brass Manufactures. Wire.		Copper and Brass Manufactures. Cartridge Cases, Coarse Wares, etc.		Glass Manufactures, All Kinds.		Gold. Bullion. Kg.		Gold. Coin. Kg.		Gold and Silver Manufactures. Kg.	
1895..	4,912	$3,800	3,975	$1,250	7,093	$4,425	118,199	$10,150	7,262	$25,050	24,738	$15,525	88,126	$7,950
1896..	5,961	4,950	5,910	1,950	6,806	4,375	108,892	9,175	34,747	24,225	40,095	25,150	96,702	5,525
1897..	5,583	4,625	6,176	2,025	5,409	3,350	105,702	9,050	32,312	22,525	11,385	7,150	101,429	9,975
1898..	6,472	5,475	5,930	2,025	6,278	3,775	102,615	7,750	4,851	3,375	82,992	52,050	98,939	10,275
1899..	7,561	6,975	7,579	3,375	5,846	3,950	107,497	6,000	4,850	3,400	48,594	30,550	107,021	12,175

Year.	Gold, Silver, and Platinum Ores.		Graphite.		Iodine.		Iron and Steel. Angle.		Iron and Steel. Blooms, Bars and Ingots.		Iron and Steel. Cast, Crude.		Iron and Steel. Man'factures, All Other.		Iron and Steel. Iron Ore.	
1895	359	$50	2,207	$100	23	$150	172,863	$4,075	61,808	$1,200	135,383	$20,450	248,355	$18,750	2,480,136	$1,850
1896	14	25	2,364	125	26	175	178,887	4,675	49,529	1,125	153,652	24,325	309,882	23,200	2,642,294	1,975
1897	53	25	2,422	125	26	150	169,287	4,400	39,792	900	170,084	26,725	296,949	22,400	3,230,391	2,400
1898	19	75	2,936	175	26	150	204,705	5,400	34,964	800	193,039	30,600	312,948	22,875	2,933,734	2,150
1899	5	(*f*)	2,703	175	26	150	221,165	7,200	(*f*)		205,935	36,075	328,880	26,075	3,119,878	2,650

Year.	Iron and Steel.—*Continued.* Iron, Pig.		Rails.		Scrap.		Wire.		Wrought, in Bars.		Lead and Copper Ores.		Lead, Pig and Scrap.		Lead, White.	
1895	135,289	$1,775	116,627	$2,550	84,814	$1,150	205,331	$6,500	277,991	$7,000	2,174	$100	27,855	$1,425	14,260	$1,025
1896	140,449	1,925	129,413	3,100	52,466	750	207,116	6,875	259,461	7,175	31,675	200	24,828	1,425	16,350	1,275
1897	90,885	1,250	113,473	2,850	38,102	550	198,909	6,625	246,772	7,075	26,817	225	24,075	1,525	14,786	1,225
1898	187,375	2,525	123,839	3,250	85,095	1,300	188,713	6,625	263,698	7,650	24,163	225	24,867	1,625	16,473	1,400
1899	182,091	3,025	109,813	3,300	53,103	1,025	154,332	6,300	193,933	6,775	35,359	1,525	24,491	1,850	16,360	1,625

Year.	Manganese Ore.		Nickel.		Oxide. (Potash.)		Phosphate Rock.		Potassium Salts. Chloride.		Potassium Salts. Cyanide.		Potassium Salts. Iodide.		Potassium Salts. Nitrate.		Potassium Salts. Sulphate.	
1895..	4,461	$125	*b* 176	$125	13,443	$1,100	5,813	$100	78,718	$2,825	48	$150	128	$875	12,928	$1,250	23,132	$775
1896..	7,178	150	143	100	12,673	1,050	5,548	100	85,862	3,075	55	125	142	950	11,323	1,750	16,019	575
1897..	8,615	100	169	100	13,100	775	4,000	75	80,389	2,850	1,086	(*f*)	124	775	8,986	850	20,971	675
1898..	4,810	75	203	125	13,456	800	5,100	75	96,236	3,375	1,907	975	135	850	10,969	1,000	27,105	850
1899..	7,040	100	295	175	11,917	900	2,504	50	101,045	3,650	1,645	825	145	900	15,146	1,375	32,845	1,150

Year.	Pyrites. (*e*)		Salt.		Silica, Sand, Marl, etc.		Silver. Crude and in Bars.		Silver. Coin.		Slag and Slag Wool.		Slag, Thomas Slag, Ground.	
1895..	14,223	$75	196,344	$600	261,195	$225	258,925	$5,750	4,303	$75	20,432	$50	80,056	$525
1896..	16,833	75	214,060	625	267,173	225	305,826	6,975	31,648	650	17,214	50	134,257	875
1897..	15,387	75	(*f*)		652,248	575	371,086	7,550	27,687	525	27,723	100	169,336	1,225
1898..	19,220	100	(*f*)		910,354	800	348,733	6,950	46,932	975	29,931	100	187,598	1,400
1899..	16,985	75	(*f*)		872,292	775	294,039	6,000	(*f*)		25,565	100	199,382	1,550

Year.	Slate.		Soda. Calcined.		Sodium Nitrate. (Chile Saltpeter.)		Stassfurt Salts.		Stone. Crude or Simply Hewn.		Stone. Limestone, Lime.		Stone. Grindstones, Polishing and Whetstones.	
1895..	4,489	$75	31,418	$775	13,437	$800	221,184	$1,375	505,163	$2,525	71,771	$275	10,465	$650
1896..	5,796	100	41,106	925	9,078	400	285,023	1,575	620,394	3,100	77,641	350	11,914	900
1897..	4,948	100	45,672	1,025	11,364	475	337,577	1,700	545,723	2,725	77,905	350	(*f*)	
1898..	4,434	100	37,106	825	12,684	525	370,829	1,750	556,561	3,225	84,892	375	(*f*)	
1899..	3,034	75	40,566	975	13,910	575	367,828	1,975	597,286	4,275	(*f*)		(*f*)	

Year.	Tin. Crude.		Tin. Manufactures		Zinc. Ore.		Zinc. Crude.		Zinc. Drawn and Rolled.		Zinc. Manufactures		Zinc-White, Zinc-Gray, and Lithophone.	
1895..	700	$225	975	$825	31,031	$350	56,933	$4,025	15,921	$1,275	1,032	$700	15,539	$1,125
1896..	868	275	1,010	850	37,959	575	58,082	4,750	16,227	1,500	1,206	825	16,969	1,325
1897..	861	275	967	800	30,047	500	51,341	4,400	17,453	1,650	1,163	800	17,631	1,325
1898..	874	325	1,119	1,000	30,408	575	51,324	5,175	14,477	1,575	1,205	850	18,674	1,775
1899..	1,121	700	1,218	1,375	25,192	575	46,334	5,675	18,281	2,425	1,561	1,125	19,489	2,175

(*a*) From *Statistisches Jahrbuch für das Deutsche Reich.* (*b*) Includes cobalt. (*c*) In 1898 and 1899 represents unglazed tile and brick only. (*d*) Previous to 1896 includes copper scrap. (*e*) Previous to 1896 includes alum ore. (*f*) Not reported.

MINERAL IMPORTS AND EXPORTS OF GERMANY FOR THE YEAR 1900. (IN METRIC TONS.)

The following figures are taken from *Chemiker Zeitung*, of Feb. 13, 1901, and while probably from official sources, are subject to correction.

Substances.	Imports.	Exports.
Alum, and aluminate of sodium and alumina, including hydrate.	121	29,372
Aluminum	943	268
Ammonium carbonate	1,904	3,196
Ammonium sulphate	23,105	2,431
Ammoniacal liquor	26,407	17,068
Antimony	1,461	131
Antimony and arsenic ore	1,290	284
Arsenic		140
Arsenic, white	225	915
Arsenical compounds	56	657
Asbestos and asbestic mastic	6,906	496
Asphalt, pitch, and wood cement	80,765	36,921
Barium chloride	3,062	3,024
Barium salts, N. E. S	127	2,903
Baryta-white	0·2	2,717
Barytes	2,117	58,685
Borax and boric acid	2,403	2,894
Brass and tombac	2,214	4,421
Bromide of potash and other bromine preparations	11	255
Bromine	0·1	191
Calcium chloride	188	1,315
Carbon bisulphide	58	203
Carbonic acid	12	558
Cement	79,303	600,386
Chloride of lime	398	25,954
Chloride of magnesium	13	13,374
Chrome alum	4·1	1,192
Chrome ore	18,726	427
Coal	7,384,049	15,275,805
Coal-tar oil, light	7,210	2,994
Coal-tar oil, heavy	3,286	10,507
Cobalt and nickel ore	13,032	185
Coke	512,690	2,229,188
Copper, crude	83,502	5,505
Copper, in bars and sheets	183	2,119
Copper alloys, in bars, sheets, etc.	723	3,154
Cinnabar	10	199
Cryolite and bauxite	30,843	358
Explosives	29	2,808
Fluorspar	93	12,749
Gold, silver, and platinum ores	9,153	21
Gold preparations and salts	1·1	63
Graphite, crude	22,495	2,068
Gunpowder	39	2,135
Gypsum	7.571	39,933
Hydrochloric acid	3,628	13,210
Iodine	236	29
Iron, crude, all kinds	827.095	190,504
Iron, wrought, in bars	37,809	172,533
Iron alum and iron mordant	1,058	459
Iron ores	4,107.790	3,247,888
Iron oxide, red	2,327	1,052
Kaolin, feldspar, and refractory clay	265,288	159,855
Lead and copper ores	62,268	26,995
Lead	70,252	18,825
Lead, white	698	15,126
Lignite	7,960,313	52,794
Litharge	444	3,577
Magnesium, artificial carbonate	73	118
Magnesium, natural carbonate	13,920	2,392
Manganese ore	204,420	2,454
Manganese preparations	315	775
Mineral oil for use in the arts	3,458	
Nickel	1,712	268
Nitric acid	1,237	1,444
Ozokerite, crude	3,457	1,451
Ozokerite, refined	263	1,632
Petroleum, crude	51,639	
Petroleum, distilled	9,761	3,470
Petroleum, refined	922,710	902
Phosphorus	381	170
Pitch, except asphalt	55,414	4,350
Potash	1,522	15,761
Potash, caustic	283	15,379
Potassium and sodium chlorate	1,688	978
Potassium chloride	483	114,469
Potassium chromate	393	726
Potassium cyanide	2	1,338
Potassium iodide and other iodine preparations	10	138
Potassium sulphate	856	38,128
Quicksilver	555	23
Salt	21,738	236,291
Saltpeter, Chile	484,544	14,158
Saltpeter, potassium	1,237	1,444
Soda, calcined	373	44,316
Soda, caustic	4,711	1,913
Soda, crude and crystallized	31	1,392
Soda chromate	253	3,014
Soda, double carbonate	203	1,314
Sodium and potassium sulphide	135	2,461
Stone, refractory, from clay	40,414	145,557
Strontia minerals	8,701	74
Strontia preparations	421	496
Sulphur	40,689	1,146
Superphosphate	72,062	77,118
Thomas slag, ground	103,481	174,563
Tin	12,454	1,626
Tin salts	118	374
Ultramarine	98	4,205
Vitriol, all kinds	3,142	6,091
Waterglass	273	5,892
Witherite	5,164	327
Zinc, ingot	24,263	51,898
Zinc ores	68,982	34,941
Zinc, sheet	145	16,709
Zinc white, zinc gray, and zinc sulphate	4,884	20,728

MINERAL PRODUCTION OF BADEN. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alumina Sulphate.		Barytes.		Coal.		Fire Clay.		Gypsum.		Iron. Cast, Foundry.	
1895	2,136	$31,779	(*b*)		4,189	$12,657	7,453	$4,130	29,805	$19,504	31,195	$1,400,720
1896	1,824	27,133	130	$97	4,001	11,003	6,819	4,267	32,801	24,651	31,356	1,730,776
1897	1,824	27,134	400	300	4,752	11,880	11,450	6,654	40,702	26,972	36,235	1,876,262
1898	2,051	30,505	1,160	825	4,133	10,333	5,112	3,529	28,037	16,137	39,988	1,876,262
1899	2,153	29,610	2,430	2,126	4,700	13,000	4,775	3,475	29,419	18,371	53,608	2,769,252

Year.	Iron.—*Continued.* Ingot.		Wrought.		Lead and Copper Ores.		Limestone. (*d*)		Manganese Ore.		Salt.	
1895	4,126	$158,077	1,047	$50,238	*c* 2·5	$105	40,188	$6,332	(*b*)		28,188	$191,252
1896	3,418	143,371	1,118	51,954	(*b*)	103	116,913	16,496	130	$325	29,227	136,993
1897	3,875	147,718	1,167	58,401	(*b*)		137,670	19,502	(*b*)		31,445	136,993
1898	3,875	147,718	1,167	58,401	(*b*)		164,979	26,104	(*b*)		31,445	136,993
1899	3,830	171,863	1,402	63,117	(*b*)		201,015	31,674	(*b*)		31,197	116,797

Year.	Sand Quartz.		Sandstone. (*e*)		Stone Porphyry.		Sulphuric Acid.		Tripoli.		Zinc Ore.	
1895	3,319	$1,901	443	$1,000	(*b*)		11,944	$65,692	8·5	$650	21	$198
1896	1,198	602	(*b*)		(*b*)		14,226	78,243	9·0	1,125	(*b*)	
1897	1,648	1,172	(*b*)		28,000	$7,000	13,365	73,507	9·0	1,800	(*b*)	
1898	1,694	910	(*b*)		7,650	1,912	13,365	73,507	6·0	575	(*b*)	
1899	1,461	798	(*b*)		22,261	5,565	13,660	68,300	11·8	1,498	357	6,245

(*a*) Reported to THE MINERAL INDUSTRY by the *Grossherzogliche Badische Domänendirektion*, Carlsruhe. (*b*) Not reported. (*c*) Lead ore only. (*d*) Including cement stone and bituminous shale. (*e*) Including millstones.

MINERAL PRODUCTION OF BAVARIA. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Barytes.		Clay. Fire Clay.		Clay. Kaolin.		Coal.		Coal, (Lignite).	
1895	3,587	$4,388	106,925	$180,188	13,250	$19,042	903,340	$2,147,594	26,531	$23,304
1896	3,397	3,404	110,174	251,899	19,080	26,268	900,080	2,129,069	35,934	33,581
1897	3,365	2,906	144,425	300,495	24,086	38,345	917,022	2,267,086	39,043	24,913
1898	4,339	6,465	282,994	671,465	29,196	35,426	964,611	2,449,264	38,663	32,842
1899	6,214	8,642	271,792	505,033	25,822	23,573	1,004,421	2,648,276	35,736	33,228

Year.	Copperas and other Sulphate.		Emery.		Feldspar.		Fluorspar.		Graphite.		Gypsum.		Iron. Ore.	
1895	637	$34,170	229	$2,353	1,115	$3,075	3,940	$5,986	3,751	$50,612	21,773	$11,597	145,191	$148,282
1896	601	32,209	249	2,527	1,315	3,145	5,218	8,280	5,248	72,108	28,799	15,334	161,279	164,262
1897	981	38,540	217	2,307	1,689	4,678	4,904	5,744	3,861	66,126	26,153	13,609	172,699	173,809
1898	886	42,663	280	2,156	1,949	8,052	4,440	5,210	4,593	97,916	25,688	13,166	171,987	178,130
1899	900	44,236	399	4,180	287	1,085	3,631	5,866	5,196	120,292	29,737	20,052	181,981	194,348

Year.	Iron.—*Continued.* Bar.		Cast, 1st Fusion.		Cast, 2d Fusion.		Pig.		Sheet.		Wire.	
1895	48,596	$1,368,013	293	$9,898	62,131	$2,868,070	77,114	$884,615	150	$5,250	100	$2,551
1896	53,573	1,587,338	114	3,993	71,006	3,378,247	79,621	907,306	(*b*)		243	6,232
1897	58,200	1,884,224	138	4,829	78,008	3,735,979	83,418	968,932	(*b*)		252	6,895
1898	58,342	1,864,479	97	3,566	84,227	4,067,760	84,144	1,005,125	(*b*)		323	9,628
1899	61,415	2,102,492	(*b*)		92,459	4,623,992	83,821	1,019,184	(*b*)		111	3,372

Year.	Iron.—*Continued.* Steel.		Manganese Ore.		Marl. (For Cement.)		Mineral Paints.		Pyrites.		Rock Salt.	
1895	96,829	$2,336,689	150	$113	85,089	$85,864	8,579	$25,945	1,955	$14,616	1,321	$8,443
1896	101,954	2,497,814	70	35	94,481	99,929	8,667	26,496	1,997	14,930	708	4,572
1897	115,530	2,851,035	130	197	97,831	60,591	8,673	25,872	2,211	7,080	1,161	5,582
1898	120,623	3,284,299	(*b*)		110,757	52,374	8,748	31,737	2,304	7,285	736	4,036
1899	134,007	3,898,125	(*b*)		220,716	79,917	9,287	33,351	2,516	7,689	802	6,610

Year.	Salt, Brine.		Silica (Quartz Sand).		Slate.		Soapstone.		Sodium Sulphate.		Stone. Flagstones.	
1895	41,106	$446,628	33,457	$10,513	1,278	$11,766	2,421	$37,979	494	$2,875	18,909	$84,685
1896	40,400	438,379	29,868	8,441	1,565	14,252	3,051	52,458	663	3,067	20,559	86,620
1897	41,533	338,029	31.678	8,812	1,496	14,001	2,464	35,360	2,318	12,749	14,647	57,343
1898	39,717	469,629	45,907	17,444	3,956	24,039	1,912	29,193	2,332	14,185	16,720	81,892
1899	41,207	422,641	39,922	17,000	2,066	22,915	2,197	33,860	1,570	8,625	20,195	95,902

Year.	Stone—*Continued.* Granite and other Massive Rocks.		Limestone.		Lithographic.		Sandstone.		Whetstone.		Sulphuric Acid.	
1895	612,969	$854,209	271,196	$69,596	8,788	$175,770	210,450	$281,893	215	$9,000	6,515	$52,800
1896	658,581	856,753	238,434	74,982	10,868	163,020	235,518	321,591	88	3,740	7,064	61,214
1897	665,749	711,029	224,550	76,385	13,941	217,821	242,112	315,117	95	3,800	7.041	63,709
1898	678,171	790,124	214,309	78,897	12,029	180,435	296,139	418,580	85	1,675	103.385	1,020,499
1899	490,712	720,632	267,180	93,891	11,962	239,240	315,786	417,917	81	1,125	123,273	1,217,000

(*a*) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (*b*) Not reported.

MINERAL PRODUCTION OF PRUSSIA. (*a*) (METRIC TONS; 4 marks = $1.)

Year.	Alum Shale		Antimony and Alloys.		Antimony Ore.		Arsenic Products.		Arsenic Ore		Asphalt.		Bismuth.	
1895	125	$188	924	$73,660	24	$218	1,788	$98,363	3,046	$30,460	14,391	$44,659	1,000	$1,750
1896	154	231	1,239	113,886	(*b*)		1,750	130,539	3,247	41,196	16,204	43,715	(*b*)	
1897	129	193	1,552	152,744	(*b*)		1,924	143,775	3,377	50,655	11,466	18,706	(*b*)	
1898	107	161	2,612	251,642	*Nil.*		1,624	121,818	3,298	49,470	12,822	20,402	*Nil.*	
1899	145	217	3,003	352,565	*Nil.*		1,469	128,543	3,265	52,406	16,458	41,149	*Nil.*	

Year.	Boracite.		Cadmium. Kg.		Coal.		Coal. (Lignite.)		Cobalt Ore.		Cobalt Products.	
1895	140	$8,256	7,047	$9,809	72,621,509	$119,888,605	20,114,877	$11,527,852	120	$6,298	45	$144,103
1896	171	9,896	10,667	20,435	78,993,655	132,782,104	21,961,201	12,195,391	181	9,868	69	220,624
1897	185	9,663	15,531	44,157	84,253,393	145,665,149	24,232,911	13,324,245	121	6,256	51	166,015
1898	216	10,162	14,943	31,162	89,593,528	160,465,335	26,035,814	14,781,896	34	1,700	44	141,952
1899	171	8,337	13,608	21,336	94,740,829	179,284,452	28,418,598	15,876,512	17	850	46	149,725

Year.	Copper.		Copper and Iron Sulphate		Copper Ore.		Copper Matte		Copper Sulphate.		Epsom Salt.	
1895	22,069	$4,980,829	112	$3,598	623,420	$3,799,452	766	$48,548	1,922	$138,905	6,789	$13,701
1896	25,683	6,398,780	126	4,266	707,395	4,186,321	369	27,098	2,568	196,592	1,793	3,971
1897	25,997	6,696,664	225	8,548	690,338	4,695,679	274	13,157	2,689	225,877	2,248	4,882
1898	27,216	7,277,385	120	4,126	691,866	4,867,052	62	2,170	1,701	139,109	2,061	4,468
1899	20,902	11,336,549	154	6,019	722,884	5,137,918	95	4,045	1,586	142,124	1,793	3,676

Year.	Gold—Kg.		Iron.		Iron Ore.		Iron Sulphate.		Lead.	
1895	653·1	$455,159	3,778,775	$43,961,347	3,726,725	$5,700,009	8,627	$30,185	99,586	$4,983,733
1896	755·2	524,958	4,470,551	55,144,390	4,053,109	7,101,832	8,618	29,383	102,413	5,621,335
1897	1,087·1	756,184	4,892,059	64,780,081	4,183,536	8,432,766	9,064	33,087	108,880	6,556,528
1898	1,036·3	719,787	5,176,943	69,822,640	4,020,809	8,135,065	9,144	31,007	119,346	7,692,050
1899	1,016·4	708,524	5,644,614	83,302,190	4,295,575	8,780,892	10,186	31,732	116,995	8,433,993

Year.	Lead Ore.		Litharge.		Manganese and Alloys.		Manganese Ore		Nickel.		Nickel Ore.		Nickel Sulphate.	
1895	140,991	$2,911,948	2,458	$137,403	66	$34,300	39,882	$105,916	698	$616,143	2,058	$4,190	91	$24,325
1896	138,308	2,998,433	2,544	153,432	86	42,225	43,614	102,384	822	713,455	738	4,540	128	31,360
1897	133,158	3,122,880	1,999	127,737	113	58,000	45,254	103,137	898	760,562	204	1,580	167	42,327
1898	133,637	3,218,107	2,360	166,554	99	51,250	42,232	96,691	1,108	706,198	79	693	127	21,690
1899	128,942	3,476,974	2,482	191,601	143	81,250	60,379	158,946	1,115	705,125	91	1,067	123	21,246

Year.	Ocher and other Mineral Paints.		Petroleum.		Potassium Salts. Kainite.		Potassium Salts. Other Potash Salts.		Pyrites.		Quicksilver. Kg.	
1895.....	2,059	$38,863	1,612	$46,446	513,097	$1,804,950	558,846	$1,707,929	115,051	$201,660	(b)	
1896.....	2,110	43,750	1,512	46,867	616,462	2,424,132	587,306	1,786,786	117,545	203,745	(b)	
1897.....	2,400	48,750	2,600	73,038	716,348	2,529,349	640,236	1,898,647	121,766	209,201	4,867	$4,684
1898.....	2,376	51,600	2,545	70,513	744,240	2,560,761	718,957	2,161,101	128,077	220,411	4,717	4,292
1899.....	2,770	57,682	3,405	91,714	744,657	2,559,169	941,055	2,622,148	134,564	234,596	2,611	3,264

Year.	Salt. Common.		Salt. Rock.		Selenium.		Silver—Kg.		Silver and Gold Ore.		Sulphur.	
1895.....	278,962	$1,757,837	278,326	$327,861	(b)		245,527	$5,376,046	12	$23,626	1,819	$34,085
1896.....	288,300	1,848,166	305,227	346,952	(b)		288,467	6,534,058	15	18,748	2,011	41,041
1897.....	274,888	1,643,473	310,755	358,697	23	$402	289,960	5,907,572	6	4,901	2,091	42,860
1898.....	286,051	1,640,214	329,959	377,162	65	1,015	291,969	5,776,802	43	2,866	1,757	38,386
1899.....	288,588	1,645,182	331,943	391,403	46	723	293,858	5,933,217	7	30,547	1,419	30,008

Year.	Sulphuric Acid.		Tin.		Zinc.		Zinc Ore.		Zinc Sulphate.	
1895.....	416,239	$3,894,871	849	$254,592	150,286	$10,397,219	706,179	$2,643,282	2,641	$39,266
1896.....	456,781	2,934,098	804	231,111	153,082	11,775,566	729,725	4,254,351	3,102	46,723
1897.....	484,289	2,890,702	912	282,384	150,739	12,608,525	663,739	4,219,761	3,583	54,601
1898.....	531,838	3,223,613	979	367,155	154,643	14,686,429	641,671	5,511,655	4,158	65,987
1899.....	573,733	3,617,024	1,461	858,581	152,987	18,215,992	663,763	8,847,039	4,864	77,585

(a) From *Zeitschrift für das Berg-, Hütten-, und Salinenwesen.* (b) Not reported.

MINERAL PRODUCTION OF SAXONY. (a) (METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Arsenical, Sulphur, and Copper Pyrites.		Barytes.		Bismuth, and Bismuth, Cobalt and Nickel Ores.		Coal. (Not Including Lignite.)		Coal. (Lignite.)		Fluorspar.	
1895....	8,900·3	$26,573	284·5	$1,045	3,001·1	$153,056	4,435,328	$10,224,100	1,018,486	$670,274	995	$1,866
1896....	8,834·9	27,080	574·2	1,554	3,168·7	141,735	4,536,603	10,778,005	1,035,825	663,590	805	1,509
1897....	9,402·0	29,112	218·4	616	3,030·6	131,952	4,571,685	11,563,214	1,073,239	666,358	592	1,110
1898....	6,410·3	16,269	477·9	1,270	3,043·4	136,167	4,436,455	11,829,001	1,180,928	728,156	775	1,453
1899....	7,442·8	23,189	215·8	587	1,161·8	131,679	4,546,756	12,435,239	1,292,348	793,712	1,355	2,541

Year.	Galena.		Iron Ocher, Swabian and Colored Earths		Iron Ore.		Limestone and Various Products. (b)		Manganese Ore.		Quartz, Mica and Uranium Ore.	
1895....	3,346·7	$172,617	415·0	$628	20·2	$107	(j)	$6,051	8	$105	26·5	$501
1896....	2,844·5	155,848	333·4	1,054	3,499·4	4,314	10·0	6,967	10	130	20·1	827
1897....	(j)		92·7	643	13,181·1	12,837	65·1	7,682	260	637	39·7	629
1898....	(j)		440·4	1,317	5,671·2	6,197	(j)	8,110	(j)		116·9	1,628
1899....	(j)		70·7	571	8,038·2	12,880	(j)	9,297	50	125	118·0	1,659

Year.	Silver Ores. (c)		Tin and Tinstone		Wolfram.		Zinc Blende.		Specimens	Totals.	
1895....	14,431·6	$493,431	154·4	$14,942	29·1	$4,289	134·6	$567	$775	5,485,561	$11,770,917
1896....	13,315·3	455,183	88·2	8,555	40 3	7,149	72·2	373	706	5,606,044	12,257,580
1897....	11,428·5	449,625	54·7	5,981	36·7	7,035	111·6	579	540	5,683,437	12,878,552
1898....	14,658·9	467,777	51·0	5,957	50·6	11,597	28·6	89	921	5,649,107	13,215,913
1899....	13,585·3	449,274	71·8	13,750	50·4	12,943	305·9	1,525	729	5,871,570	13,883,700

Year.	Manufactured Products. From a Part of the Coal. Briquettes—M.		From a Part of the Coal. Coke.		From a Part of the Lignite. Briquettes—M.		From a Part of the Lignite. Lignite Bricks—M.	
1895.....	1,412	$6,917	70,449	$252,420	99,228	$68,245	65,353	$115,255
1896.....	1,981	7,997	77,086	299,248	123,571	81,933	58,374	104,506
1897.....	(k) 3,547	13,517	77,507	331,863	(k) 53,460	107,451	60,166	105,456
1898.....	(k) 5,321	18,363	72,245	340,685	(k) 71,576	143,438	62,244	112,804
1899.....	(k) 8,457	29,659	74,284	362,065	(k) 91,518	181,411	60,954	107,347

METALLIC CONTENTS OF THE MIXED ORES INCLUDED IN THE PRECEDING TABLE WHICH WERE DELIVERED TO THE FISCAL SMELTING WORKS AT FREIBERG. (*a*)
(IN METRIC TONS; 4 marks = $1.)

Year.	Total Mixed Ores.		Arsenic. Tons.	Copper. Tons.	Gold. Kg.	Lead. Tons.	Nickel and Cobalt. Kg.	Silver. Kg.	Sulphur. Tons.	Zinc. Tons.
1895.....	26,679	$694,131	350·1	14 9	0·1314	4,739·8	60·3	29,383·3	3,905·0	81·9
1896.....	24,923	638,237	303·2	20·0	0·1736	3,887·5	130·1	26,268·0	3,784·9	122·6
1897.....	20,772	477,664	353·1	9·6	0·1396	5,016·2	(*j*)	21,974·5	7,398·3	124·6
1898.....	31,724	658,756	85·4	3·5	(*j*)	5,769·7	(*j*)	21,404·9	5,445·9	305·3
1899.....	20,956	472,089	242·3	2·1	(*j*)	2,717·4	(*j*)	18,306·1	4,070·5	118·2

PRODUCTS SOLD BY THE FISCAL SMELTING WORKS AT FREIBERG AND THE COBALT WORKS AT SCHNEEBERG, GERMANY. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Arsenical Products. (*d*)		Bismuth. Kg.		Cobalt Products.		Copper Sulphate.		Fine Gold. Kg.		Lead.			
											Products. (*e*)		Sheet.	
1895....	1,217	$108,826	2,529	$4,738	406	$353,768	1,833	$137,557	850	$592,497	6,603	$345,129	592	$32,622
1896....	882	90,626	1,112	1,765	599	431,318	2,547	197,421	847	590,227	5,810	333,744	830	50,953
1897....	1,063	127,122	1,624	3,801	628	581,559	1,878	162,881	889	619,831	5,421	332,652	634	41,626
1898....	1,053	131,710	1,375	3,774	631	620,217	1,777	146,164	851	579,519	7,456	486,095	647	45,710
1899....	953	138,572	1,300	3,443	645	705,347	2,550	228,933	832	581,001	6,422	463,557	1,012	77,254

Year.	Lead.—*Continued.*				Nickel, Speiss.		Fine Silver—Kg.		Sulphuric Acid. (*g*)		Other Chemicals. (*h*)	
	Shot.		Other Manufactures of. (*f*)									
1895....	238	$14,613	218	$13,563	26	$1,052	54,770	$1,211,118	10,205	$113,419	624	$6,744
1896....	149	10,001	213	14,874	83	7,195	46,577	1,063,337	9,238	97,812	499	5,788
1897....	142	9.850	224	15,771	75	4,166	72,862	1,465,076	10,783	73,450	472	5,672
1898....	127	9.515	218	16,746	56	3,409	79,555	1,583,071	11,574	102,639	545	5,820
1899....	203	16,851	301	26,759	54	3,469	85,741	1,743,021	11,844	113,776	565	5,485

Year.	Zinc and Zinc Dust.		Clay and Chamotte Manufactures. (*i*)	Total Value.
1895....	163	$11,886	$11,729	$2,959,263
1896....	16	1,347	12,593	2,909,003
1897....	120	10,483	16,855	2,907,602
1898....	227	21,978	18,478	3,774,873
1899....	169	21,729	16,402	4,145,102

(*a*) From *Jahrbücher für das Berg- und Hüttenwesen im Königreiche Sachsen.* (*b*) Including arsenic powder, slags, washing-sand, granular ore, refuse stones and chippings. (*c*) Including silver-bearing lead, copper, arsenic, zinc and sulphur ores. (*d*) Including arsenious acid, red, yellow and white glass, and metallic arsenic. (*e*) Including assay lead, soft lead, antimonial lead, litharge, lead fume and tin-lead. (*f*) Including lead pipes, lead wire and various lead apparatus. (*g*) Including sulphuric acid of all kinds. (*h*) Including copperas and glauber salt. (*i*) Including tiles, plates, figured stone, muffles, clay and graphite crucibles, and assaying utensils. (*j*) Not reported. (*k*) Quantity stated in tons.

GREECE.

THE statistics of mineral production in Greece are summarized in the following tables:

MINERAL PRODUCTION OF GREECE. (*a*) (*c*) (METRIC TONS AND DOLLARS; 1 drachma=20 cents.)

Year.	Blende.		Calamine, Calcined.		Chrome Ore.		Emery.		Gypsum.		Iron Ore.		Iron Ore, Manganiferous.	
1895..	2,710	$45,230	21,321	$395,250	2,740	$34,120	3,055	$45,825	113	$2,030	150,210	$179,250	152,123	$342,670
1896..	1,750	31,520	20,950	301,680	1,600	22,400	3,650	77,745	120	2,150	225,600	314,700	166,850	417,120
1897..	3,118	58,826	22,817	489,357	563	8,087	3,024	64,411	51	918	260,828	375,592	182,850	499,180
1898..	1,139	22,320	30,906	562,490	1,367	18,000	3,932	83,754	83	1,500	287,100	413,230	213,938	641,840
1899..	1,137	30,936	21,770	539,890	4,386	55,310	4,360	92,868	81	1,465	331,030	499,430	204,320	896,500
1900..	(*b*)		18,751	395,270	5,600	70,200	6,328	134,786	129	2,281	279,880	481,394	243,920	782,940

Year.	Lead, Soft.		Lead Ore, Argentiferous.		Lead, Argentiferous.		Lead Fume.		Lignite.		Magnesite, Crude.	
1895..	7	$490	1,580	$147,400	19,838	$1,656,500	1,406	$12,020	17,748	$55,500	11,096	$33,288
1896..	480	28,900	3,200	137,600	14,700	1,325,095	1,550	10,510	14,000	28,000	11,600	34,800
1897..	520	33,904	2,815	125,174	15,946	1,524,977	2,785	26,333	20,018	40,000	11,311	39,500
1898..	305	21,655	(*b*)		18,888	1,832,136	2,655	27,248	17,310	34,620	14,829	54,100
1899..	291	23,862	(*b*)		18,768	2,156,443	2,584	28,424	12,150	24,300	17,184	63,580
1900..	245	19,650	878	64,974	16,150	1,676,510	2,045	23,720	12,940	25,200	17,277	62,197

Year.	Magnesite, Bricks.		Magnesite, Calcined.		Manganese Ore.		Millstones. *Number.*		Puzzolan.		Sea Salt.		Sulphur.	
1895..	(*b*)		(*b*)		7,250	$42,750	(*b*)	$10,020	29,810	$26,830	22,238	$335,800	1,480	$31,970
1896..	(*b*)		(*b*)		15,500	93,600	(*b*)	8,200	31,300	30,100	22,800	344,280	1,540	35,500
1897..	826	$18,172	686	$7,550	11,868	73,580	6,975	3,785	42,600	38,340	20,421	308,357	358	7,518
1898..	516	11,352	129	1,160	14,097	90,220	18,500	9,500	70,700	72,114	25,250	363,600	135	2,880
1899..	542	19,512	3,087	71,100	17,600	98,560	12,563	6,307	46,375	39,882	37,125	579,150	1,150	24,150
1900..	534	19,225	807	17,754	8,050	45,170	13,386	8,305	49,426	42,506	22,411	336,165	891	19,424

(*a*) Statistics communicated by E. Grohmann, Seriphos. (*b*) Not stated. (*c*) There was produced also in 1898 ocher, 40 metric tons, value, $104; in 1899 speiss from lead smelting, 1,100 metric tons ($12,760); in 1900, abestos, 9 tons ($72); soapstone, 97 tons ($585); speiss from lead smelting, 3,767 tons ($41,566).

INDIA.

THE official statistics of mineral production in British India, and the imports and exports, are summarized in the subjoined tables:

MINERAL PRODUCTION OF INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees = $1.)

Year.	Alum.		Asbestos. Kg.		Borax.		Clay.	Coal.		Copper Ore.		Fullers Earth.	
1895.....	418	(*b*)	205	$910	400	$27,880	$814,945	4,441,681	$2,904,167	(*b*)		40,360	$3,066
1896.....	418	(*b*)	304	12	340	30,034	830,922	3,909,764	3,065,067	22	$210	(*b*)	
1897.....	509	(*b*)	254	10	280	23,622	(*c*)	4,128,330	3,116,647	33	69	318	125
1898.....	762	$15,750	254	10	(*b*)		(*c*)	4,678,640	3,576,167	(*b*)		(*b*)	
1899.....	4	117	51	2	(*b*)		508,862	5,016,055	3,884,968	52	256	(*b*)	

Year.	Gold—Kg.		Granite. (*c*)		Graphite.		Gypsum.		Iron Ore.		Laterite.	
1895.....	7,741	*c*$3,511,607	1,188,840	*d*$108,216	(*b*)		6,816	$776	46,552	$55,688	5,678.001	$56.906
1896.....	10,662	5,314,617	835,697	*d*124,777	(*b*)		7,605	1,017	13,996	22,225	5,867,878	*c*70,235
1897.....	12,100	5,581,439	633,302	*d*129,381	61		8,187	1,082	44.009	38,075	5,399,794	*c*94.074
1898.....	12,773	6,031,890	806,131	*d*123,815	22		8,390	1,160	50,559	46,902	6,173,887	(*c*)
1899.....	14,214	6,461,560	917,776	*d*136,444	1,548	*c*$5,825	6,546	592	61,697	46,343	6,010,582	*c*493,826

Year.	Limestone.		Manganese Ore		Mica.		Ochers.		Petroleum—*Gallons.*		Rubies.
1895.....	1,109,272	$89,797	16,070	(*b*)	382	$63,322	5,772		13,013,990	$308,518	$72,839
1896.....	1,135,730	128,291	57,782	$113,738	538	85,617	(*b*)		15,057,094	448,339	171,884
1897.....	1,861,309	195,673	74,862	147,500	703	49,751	(*b*)		19,128,828	565,943	200,613
1898.....	1,924,577	(*c*)	61,469	120,900	271	56,265	(*b*)		18,972,368	254,580	217,313
1899.....	2,188,985	371,791	88,520	65,344	630	227,378	(*b*)		32,934,007	471,315	340,993

Year.	Salt.		Saltpeter.		Sandstone.		Slate. (*c*)		Soapstone. (*c*)		Tin Ore. (*c*)		Trap Rock. (*c*)	
1895....	1,120,780	$1,225,180	11,583	$489,190	831,921	*c*$32,811	60,165		343	$972	22	$4,464	29,038	
1896....	1,043,171	1,369,821	16,140	567,200	1,001,245	*c* 80,521	22,840	$9,708	789	2,719	82	20,361	107,956	$5,447
1897....	937,932	1.219,074	12,819	440,630	956,532	*c* 48,328	26,589	10,102	1,003	3,915	62	9,888	140,764	19,629
1898....	1,043.828	1,485.702	11,702	402,560	*c*1,174.454	(*c*)	26,954	10,755	1,839	(*b*)	40	9,572	128,772	(*c*)
1899....	977,240	1,324,748	11,397	408,660	1,070,799	134,369	26,372	13,359	735	5,111	50	17,987	358,871	255,705

(*a*) From the *Review of the Mineral Production in India*; and the *Annual General Report upon the Mineral Industry of the United Kingdom of Great Britain*. (*b*) Not stated in the reports. (*c*) Incomplete. (*d*) Represents only a part of the product, about one-third in 1895, and one-half in 1896, 1897, 1898 and 1899.

MINERAL IMPORTS OF BRITISH INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees = $1.)

Year. (*b*)	Alum.		Arsenic.		Asphalt.		Brass.		Cement.		Chalk and Lime.		Clay Products. Clays.	
1894–95...	3,632	$91,855	76	$6,980	1,055	$13,937	445	$119,238	28,048	$279,702	2,688	$12,975	1,328	$12,242
1895–96...	4,050	99,550	122	12,705	1,387	19,502	543	150,182	36,408	356,302	1,607	6,055	2,910	30,670
1896–97...	2,738	62,372	88	7,870	883	12,002	499	144,675	29,196	278,617	1,745	4,875	2,326	22,720
1897–98...	5,248	115,980	98	9,520	1,082	13,307	670	187,542	37,354	371,690	1,040	5,177	2,788	26,950
1898–99...	3,607	70,637	119	11,490	1,090	12,725	443	136,800	36,170	369,797	1,735	7,757	2,914	24,332
1899–1900.	3,351	87,020	103	13,660	715	11,745	518	205,780	37,058	500,330	2,040	11,250	2,235	25,950

Year. (*b*)	Clay Products.—*Continued.* Brick and Tile. *Number.*		Earthenware and Porcelain.		Earthenware (Piping).		Coal.		Coke.		Copper and Copper Manufactures.		Glassware.
1894–95...	2,337,410	$41,275	$482,108	2,268	$41,017	821,926	$3,580,238	12,624	$93,247	17,988	$3,779,540	$1,549,990	
1895–96...	2,328,741	45,270	578,555	1,011	21,163	758,799	3,390,590	14,626	112,635	*c*23,968	5,224,837	1,852,695	
1896–97...	3,915,291	72,475	537,752	1,391	26,400	488,732	2,326,890	13,588	117,352	12,237	2,688,535	1,760,460	
1897–98...	4,507,161	69,637	512,605	785	15,370	251,574	1,213,220	15,027	130,160	16,383	3,554,325	1,441,680	
1898–99...	3,544,390	69,032	468,372	829	14,162	352,540	1,651,390	11,573	86,567	12,766	2,803,190	1,655,732	
1899–1900.	3,641,594	71,420	663,455	663	13,655	404,382	2,451,040	13,899	162,885	4,615	1,763,790	2,555,505	

Year. (*b*)	Iron, Pig.		Iron and Steel, Manufactures of.		Lead. Ore.		Lead. Pig.		Lead. Manufactures		Mineral Oils. *Gallons.*	
1894–95...	*d*8,163	$108,995	203,046	$7,077,455	176	$10,392	712	$33,860	4,828	$360,577	53,441,425	$4,854,915
1895–96...	10,213	142,490	279,472	9,599,703	137	8,712	1,050	54,400	4,993	372,178	66,647,921	6,949,358
1896–97...	13,278	190,152	262,562	9,131,382	309	17,810	709	36,865	5,252	368,720	68,421,148	7,720,697
1897–98...	11,045	155,355	281,253	9,847,455	160	9,855	547	28,302	5,098	351,545	87,325,026	8,494,467
1898–99...	12,407	158,290	239,637	8,169,988	211	13,140	706	38,242	4,204	291,610	76,625,406	7,464,680
1899–1900.	13,389	265,015	211,892	11,135,815	283	24,050	613	55,115	4,318	443,265	70,440,116	9,799,940

Year. (*b*)	Paints and Colors.		Precious Stones.	Quicksilver		Salt.		Stone and Marble.		Tin and Tin Manufactures.		Zinc and Zinc Manufactures.	
1894–95...	8,888	$556,977	$1,422,748	54	$46,897	516,509	$2,105,482	41,548	$91,502	2,459	$801,750	4,304	$307,680
1895–96...	9,685	704,942	1,630,878	160	152,038	413,787	1,633,065	43,094	72,250	2,556	823,527	4,564	312,750
1896–97...	9,696	674,395	1,321,700	118	102,992	333,557	1,571,360	24,880	62,930	1,849	551,342	2,277	175,580
1897–98...	9,238	670,680	1,126,225	143	119,050	494,503	2,171,795	36,745	96,485	1,962	554,078	3,185	244,312
1898–99...	10,159	643,257	(*e*)	115	99,895	418,455	1,653,067	31,200	78,552	1,483	416,930	3,795	291,012
1899–1900.	9,263	884,743	(*e*)	87	113,455	423,302	2,039,985	29,405	98,790	884	461,375	3,916	464,715

(*a*) From the *Tables Relating to the Trade of British India.* (*b*) Fiscal years ending March 31. (*c*) Also imported 2 tons copper ore, value $287. (*d*) Also imported, 1893–94, 5 cwt. iron ore, value $7; 1896–97, 2 metric tons, $82; in 1897–98, 52 metric tons, $735, and in 1898–99, 597 metric tons of ore and old iron, $6,932. (*e*) Not reported.

MINERAL EXPORTS OF BRITISH INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees = $1.)

Year. (*b*)	Borax.		Brass.		Coal and Coke.		Copper, and Manufactures of.		Earthenware and Porcel'n.	Glassware.	Jadestone.		Lead.	
1894–95...	400	$34,852	179	$89,620	54,523	$120,557	112	$35,700	$11,532	$13,642	229	$113,265	129	$5,390
1895–96...	340	30,035	204	127,325	82,217	216,450	123	38,817	12,842	14,997	215	136,538	57	3,115
1896–97...	280	23,622	188	106,012	138,906	352,810	111	35,930	11,432	12,897	219	153,780	210	8,427
1897–98...	184	16,277	162	76,755	216,261	535,340	84	26,325	10,157	11,717	196	150,025	117	5,127
1898–99...	250	24,107	156	70,937	332,307	838,257	130	40,062	8,802	12,742	228	156,075	193	7,215
1899–1900.	224	31,520	270	138,635	309,459	1,093,370	494	364,795	13,200	21,430	142	284,785	237	12,595

Year. (*b*)	Manganese Ore.		Mica.		Mineral Oils. *Gallons.*	Precious Stones.	Saltpeter.		Stone and Marble.		Tin.		
1894–95	6,518	$12,832	261	$159,437	48,391	$2,522	$21,162	17,931	$1,028,362	226	$9,050	71	$19,972
1895–96	23,122	45,515	452	268,052	315,118	38,817	37,287	21,425	1,339,865	315	10,555	13	3,437
1896–97	48,087	94,660	652	288,340	191,424	28,225	34,670	26,845	1,430,410	499	14,072	86	20,362
1897–98	80,090	157,507	590	267,142	15,563	2,860	30,970	21,218	996,862	995	16,010	49	10,945
1898–99	62,875	125,830	556	202,087	722,686	90,960	29,012	18,263	873,360	688	14,215	43	10,982
1899–1900	96,749	254,015	1,148	366,860	325,922	53,430	78,470	20,188	1,280,980	20	1,110	39	23,120

(*a*) From the *Tables Relating to the Trade of British India.* (*b*) Fiscal years ending March 31. (*c*) Not reported.

ITALY.

THE official statistics of mineral and metal production in Italy, together with the imports and exports as reported in the official statistics of the Kingdom, are summarized in the following tables:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

Year.	Alum.		Aluminum. Sulphate.		Alunite.		Antimony.		Antimony Ore.		Asphalt, Mastic and Bitumen.	
1895.....	*b*1,115	$21,000	2,950	$53,760	7,000	$5,600	423	$56,986	2,241	$40,254	14,491	$75,920
1896.....	850	16,260	2,390	41,020	6,000	6,000	538	72,440	5,086	60,590	12,490	75,280
1897.....	1,030	21,180	2,310	40,160	6,500	6,500	404	57,072	2,150	34,864	18,644	89,125
1898.....	1,165	25,060	2,915	54,560	7,000	7,000	380	62,550	1,931	43,822	17,813	111.611
1899.....	945	22,350	2,330	43,287	5,800	5,800	581	87,900	3,791	44,862	41,732	248,084

Year.	Asphaltic Rock.		Barytes.		Borax, Refined.		Boric Acid, Crude.		Boric Acid, Refined.		Coal. (*c*)	
1895.....	46,713	$204,750	(*d*)		944	$101,930	2,633	$184,310	253	$29,807	305,321	$433.555
1896.....	45,456	177,728	(*d*)		943	79.279	2,616	167,424	253	32,838	276,197	396,372
1897.....	55,339	189,655	(*d*)		990	83,160	2,704	173,056	260	31,200	314,222	467,111
1898.....	93,750	265,645	12,400	$74,400	702	50,558	2,650	163,600	166	16,590	341,327	485,965
1899.....	81,987	230,589	12,545	87,653	709	51,084	2,674	171,136	129	11,619	388,534	551,844

Year.	Coal. (Briquettes.)		Coke.		Copper.		Copper Ore.		Gold—Kg.		Gold Ore.	
1895.....	451,470	$2,527,564	394,043	$2,615,204	2,375	$577,352	83,670	$367.516	280·0	$199,453	7,099	$129,887
1896.....	422,409	2,081,645	426,906	2,695,109	2,842	768,160	90,408	424,719	274·7	189,024	7,659	170,602
1897.....	549,050	2,768,350	430,617	2,669,285	2,980	749,954	93,377	431,229	316·0	218,862	10,723	178,010
1898.....	594,500	3,373,900	469,228	2,943,821	3,230	878,509	95,128	426,299	187·9	131,818	9,549	148,826
1899.....	566,000	3,262,000	485,951	3,102,354	3,032	1,164,697	94,764	687,772	113·3	79,095	11,859	91,416

Year.	Graphite.		Iron. Ore.		Iron. Bar, Sheet, Pipe, Wire, etc.		Iron. Pig.		Iron. Sheet, Tinned.		Iron. Steel.	
1895.....	2,657	$8,599	183,371	$405,711	163,824	$6,962,837	9,213	$207,948	5,860	$555,360	50,314	$3,794,256
1896.....	3,148	10,193	203,966	507,973	139,991	6,606,951	6,987	192,681	2,918	256,784	65,955	4,874,539
1897.....	5,650	11,300	200,709	572,102	149,944	7,176,951	8,393	181,763	6,500	546,000	63,940	4,156,850
1898.....	6,435	17,423	190,110	549.248	167,499	8,173,165	12,387	259,897	7,200	660,000	87,467	5,417,096
1899.....	9,990	55,944	236,549	706,823	197,730	10,961,105	19,218	521,428	8,000	960,000	108,501	6,759,501

Year.	Lead.		Lead Ore.		Manganese Ore.		Manganiferous Iron Ore.		Marble.		Petroleum.		Petroleum, Benzine, etc.	
1895..	20,353	$1,078,920	30,632	$813,324	1,569	$14,128	5,860	$9,376	186,900	(*d*)	3,594	$186,099	4,191	$440,953
1896..	20,786	1,162,469	33,545	892,865	1,890	20,450	10,000	20,000	209,428	(*d*)	2,524	128,894	2,734	296,147
1897..	22,407	1,462,909	36,200	1,008,525	1,634	15,008	21,262	34,019	236,958	(*d*)	1,932	98,456	3.392	279,533
1898..	24,543	1,646,865	33,930	1,044,248	3,002	18,707	11,150	26,760	271,725	$2,109,440	2,015	117,826	5,040	395.821
1899..	20,543	1,580,423	31,046	1,122,161	4,356	22,432	29,874	77,149	313,744	2,438,624	2,242	118,812	5,384	420,710

Year.	Pumice.		Pyrites. (Cupriferous in part.)		Quicksilv'r.		Quicksilver Ore.		Salt. Brine.		Salt. Rock.		Salt. Sea.	
1895..	(*d*)		38,586	$85,741	199	$189,308	10,504	$166,680	10,605	$54,171	18,710	$56,019	448,335	$957.529
1896..	(*d*)		45,728	108.825	186	174,840	14,305	147,570	11.974	61,298	17,300	52.024	422,555	856,072
1897..	(*d*)		58,320	156,028	192	192,000	20.659	157,782	11,725	63,100	19,801	54,404	429,253	885,637
1898..	2,766	$41,678	67,191	165,610	173	173,000	19.201	132,223	11,546	59,568	18,199	61,147	451,426	710,501
1899..	7,300	141,620	76,538	198,859	205	246,000	29,322	191,544	11,021	63,950	17,821	60,468	363,826	514,074

Year.	Silver—Kg.		Silver Ore.		Sulphur. Crude. (Fused.)		Sulphur. Ground.		Sulphur. Refined.		Talc.	
1895.....	44,189	$1,007,460	870	$128,273	370,766	$4,134,588	91,517	$1,473,063	75,329	$1,125,494	(d)	
1896.....	38,075	882,228	640	107,251	426,353	6,134,253	89,292	1,602,797	71,072	1,198,447	(d)	
1897.....	45,313	917,670	405	85,625	496,658	8,995,647	69,178	1,541,510	85,872	1,874,642	(d)	
1898.....	43,437	894,157	435	76,048	502,351	9,708,050	146,001	3,259,999	99,494	2,273,053	12,760	$44,970
1899.....	33,645	720,022	540	116,652	563,697	10,769,342	161,509	3,602,450	110,213	2,481,727	11,000	73,687

Year.	Zinc.		Zinc Ore.	
1895.....	*Nil.*		121,197	$1,542,905
1896.....	*Nil.*		118,171	1,498,129
1897.....	250	$22,500	122,214	1,656,065
1898.....	250	27,000	132,099	2,412,333
1899.....	251	27,662	150,629	4,846,666

(*a*) From *Rivista del Servizio Minerario.* (*b*) Including 120 tons of soda alum. (*c*) Includes anthracite lignite, fossil-wood, and bituminous schist. (*d*) Not reported.

MINERAL IMPORTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

Year.	Antimony.		Arsenic—Kg.		Asbestos.		Asphaltic Prod. (Bitumen.)		Barytes.		Borax and Boric Acid.	
1895.....	42	$7,238	1,200	$348	531	$47,772	6,075	$97,205	508	$13,205	177	$19,475
1896.....	38	6,112	(*f*)		851	76,572	11,892	190,277	549	14,284	166	18,249
1897.....	66	10,512	3,200	928	619	61,890	1,632	26,120	578	15,025	253	24,221
1898.....	58	11,077	700	203	1,186	118,640	1,150	18,405	860	22,365	147	10,786
1899.....	635	13,335	600	182	1,675	167,500	1,473	23,566	936	24,346	123	10,110

Year.	Cement and Hydraulic Lime.		Chalk.		Clay Products. Brick, Tile, etc.		Clay Products. Kaolin.		Clay Products. Majolica Wares.		Clay Products. Porcelain.	
1895.....	15,120	$136,080	17,102	$119,714	14,623	$103,193	2,924	$23,392	416	$18,109	484	$132,181
1896.....	12,810	115,290	15,716	110,012	18,504	129,528	3,775	30,200	439	20,293	441	123,128
1897.....	16,680	150,120	28,937	202,559	19,086	133,602	5,719	45,752	476	24,637	472	126,548
1898.....	12,029	108,261	18,252	127,764	21,681	151,767	9,079	72,632	101	4,922	588	100,519
1899.....	14,391	125,178	13,738	96,166	22,410	156,870	12,105	96,840	461	6,230	894	248,268

Year.	Clay Products.—*Continued.* Potters' Clay and Manufactures.		Clay Products.—*Continued.* Terra Cotta.		Coal.		Copper Ore.		Copper Cement.	
1895.....	748	$117,060	2,533	$79,194	4,304,787	$17,219,148	1,600	$160,000	440	$61,600
1896.....	787	120,820	2,675	84,622	4,081,218	17,141,116	484	67,760	1,150	184,000
1897.....	743	116,980	2,167	69,621	4,259,643	19,594,358	1,611	225,540	1,049	167,840
1898.....	825	129,330	2,132	67,785	4,431,524	27,475,449	5,471	820,650	2,040	354,960
1899.....	773	123,490	2,200	68,554	4,859,556	30,129,246	2,777	555,400	1,328	239,040

Year.	Copper, Brass and Bronze.		Copper and Iron Sulphates.		Glass and Manufactures.		Gold. Coin—Kg.		Gold. Unrefined. Kg.		Gold. Man'fact'res Kg.	
1895.....	6,661	$2,431,779	14,124	$1,128,992	11,237	$924,776	784	$486,080	1,119	$581,880	1,851	$775,990
1896.....	6,955	2,592,932	24,255	2,037,462	9,322	813,134	1,004	622,480	2,517	1,308,840	1,515	570,446
1897.....	7,999	2,678,833	28,878	2,656,849	11,182	937,282	444	275,280	807	419,640	1,375	459,240
1898.....	7,433	2,645,153	25,560	2,351,538	10,399	863,916	154	95,480	507	263,640	1,844	641,785
1899.....	7,334	3,802,699	27,408	3,453,383	10,303	939,677	181	112,220	326	169,520	1,390	520,170

Year.	Graphite.		Iron. Ore.		Iron. Pig.		Iron. Wrought.		Iron and Steel. Plates, Rods and Manufactures.		Iron and Steel. Scrap.	
1895.....	216	$12,978	1,742	$3,484	131,870	$2,109,920	5,393	$326,064	63,672	$6,880,541	179,802	$2,697,034
1896.....	204	12,264	594	1,425	119,491	1,911,854	4,820	327,413	52,202	6,919,787	162,035	2,430,526
1897.....	315	18,882	5,331	15,161	156,019	2,496,310	3,801	269,378	88,895	5,179,932	130,938	1,964,076
1898.....	552	26,726	8,723	23,552	169,059	2,874,010	4,076	307,371	98,564	5,533,233	138,426	2,214,811
1899.....	608	42,581	20,799	58,237	191,613	4,213,495	4,158	387,234	142,645	7,132,446	245,616	4,666,710

Year.	Lead. Ore. (c)		Lead. And Alloys in Pigs.		Lead. Manufactures.		Lead Oxide and Carbonate.		Mineral Paints.		Nickel Alloys and Manufactures.	
1895	8,901	$284,832	947	$53,043	233	$42,639	848	$65,356	934	$22,406	248·6	$304,826
1896	9,730	408,660	1,166	69,978	192	39,524	523	41,037	852	20,441	411·3	473,139
1897	14,854	653,576	1,178	75,424	247	54,481	580	43,211	888	21,305	432·4	473,386
1898	10,947	503,562	1,431	100,142	435	75,950	647	54,314	692	16,606	257·7	345,793
1899	7,476	373,800	3,990	319,232	249	51,304	662	60,859	958	23,004	250·0	235,536

Year.	Petroleum.		Phosphate Rock.		Potash, Ammonia and Caustic Soda.		Potassium Sulphate.		Precious Stones, Manufactures. Kg.	
1895	68,617	$2,401,595	(*f*)		9,907	$439,140	262	$14,683	454·1	$1,897,948
1896	70,217	2,387,388	(*f*)		9,841	458,037	431	24,142	478·9	1,505,464
1897	68,973	2,207,139	(*f*)		11,012	528,537	562	30,375	490·8	2,033,714
1898	70,654	2,402,253	65,126	$781,500	11,047	493,393	928	50,101	318·6	1,629,008
1899	71,391	2,998,409	116,283	1,395,396	12,370	533,413	1,297	75,214	350·1	1,323,317

Year.	Salt.		Silver. Coin—Kg		Silver. Unrefined in Bars—Kg.		Silver. Manufactures. Kg.		Quicksilver.		Slag.	
1895	(*f*)		9,768	$390,720	2,845	$56,900	6,070	$102,887	10	$9,373	11,316	$113,156
1896	(*f*)		22,751	910,040	2,291	48,111	6,533	125,212	30	27,180	30,275	363,294
1897	(*f*)		26,008	1,040,320	2,434	43,812	5,286	91,453	30	27,270	37,201	409,208
1898	26,686	$96,070	8,241	329,640	991	17,838	5,673	86,594	39	37,440	51,139	563,137
1899	(*f*)		20,605	824,200	1,782	32,789	4,881	80,005	62	68,420	56,549	678,592

Year.	Sodium Salts. Carbonate.		Sodium Salts. Nitrate. (Crude.)		Sodium Salts. Refined, and Potassium Nitrate.		Tin. Bars.		Tin. Manufactures.	
1895	19,949	$359,078	12,670	$582,825	569	$39,865	1,484	$516,432	87	$35,520
1896	18,927	329,335	11,685	537,501	541	40,320	1,763	581,955	91	35,156
1897	20,721	393,699	16,400	705,204	917	69,946	1,520	501,732	81	31,560
1898	20,845	458,588	19,961	818,409	702	48,478	1,722	688,680	109	50,341
1899	22,654	498,386	22,385	940,170	671	56,659	1,240	842,996	96	63,380

Year.	Zinc. Ore.		Zinc. Oxide.		Zinc. Pigs and Old.		Zinc. Manufactures.		Metals Not Specified. Crude.		Metals Not Specified. Manufactures.	
1895	22	$330	576	$57,640	2,378	$190,240	3,136	$344,390	933	$69,064	18	$9,308
1896	(*f*)		540	54,020	2,596	233,640	3,482	421,918	1,135	90,768	21	10,972
1897	(*f*)		570	57,000	3,278	295,038	3,556	421,153	1,509	114,661	30	15,756
1898	216	4,320	573	63,008	2,813	303,793	3,200	441,066	1,612	128,944	27	14,416
1899	(*f*)		804	96,468	3,498	461,776	3,221	523,130	2,726	245,331	15	7,897

(*a*) From the *Movimento Commerciale del Regno d'Italia.* (c) Includes argentiferous lead ore. (*f*) Not reported.

MINERAL EXPORTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

Year.	Antimony.		Asbestos.		Asphaltic Product. (Bitumen.)		Barytes.		Borax and Boric Acid		Cement and Hydraulic Lime.	
1895	254	$44,213	29	$2,637	9,535	$57,213	1,054	$27,399	2,591	$244,275	4,534	$36,272
1896	361	57,760	130	11,673	13,729	92,375	66	1,705	2,719	252,785	3,871	30,968
1897	271	43,344	170	11,893	15,310	244,960	143	3,723	1,618	145,676	5,330	42,640
1898	338	64,315	208	16,672	19,465	311,440	70	1,828	2,167	143,925	5,192	41,536
1899	240	50,402	245	19,568	26,402	422,432	45	1,165	2,872	209,783	5,462	43,062

Year.	Chalk.		Clay Products. Brick, Tile, etc.		Clay Products. Kaolin.		Clay Products. Porcelain.		Clay Products. Potters' Clay and Manufactures.		Clay Products. Terra Cotta.	
1895	3,719	$18,595	127,177	$727,210	23	$184	161	$35,566	591	$90,010	2,509	$79,737
1896	5,593	27,965	143,648	809,823	49	392	99	24 912	1,143	157,100	2,852	97,548
1897	7,556	37,780	125,925	710,155	93	744	138	38,164	1,292	174,910	2,472	85,653
1898	6,744	40.504	125,614	711,039	94	752	86	28,476	1,347	196.600	2,751	98,254
1899	5,386	32,316	136,402	769,182	94	658	124	39,253	1,579	238,040	2,796	102,292

Year.	Coal.		Copper Ore.		Copper, Brass and Bronze.		Copper & Iron Sulphates.		Glass and Manufactures of.		Gold. Coin—Kg.	
1895.....	16,497	$65,988	5,859	$87,885	268	$113.300	12	$960	6,327	$1,198,147	3,139	$1,946,180
1896.....	18,924	71,481	3,603	61,251	643	225,211	71	5,998	5,867	1,066,612	2,483	1,539,460
1897.....	23,191	106,679	2,408	40,936	641	281,764	18	1,638	6,022	1,015,225	1,608	996,960
1898.....	17,749	110,044	2,356	42,408	857	169,986	25	2,300	5,209	849,328	2,566	1,590,920
1899.....	20,803	128,979	1,148	28,900	1,734	808,214	20	2,507	5,930	1,021,111	2,067	1,281,540

Year.	Gold.—*Con.* Unrefined. Kg.		Graphite.		Iron. Ore.		Iron. Pig.		Iron. Wrought.		Iron and Steel. Plates, Rods and Manufactures.	
1895.....	2,759	$1,434,680	3,153	$25,226	164,367	$328,734	966	$15,454	430	$27,510	2,468	$266,465
1896.....	2,517	1,308,840	3,727	29,817	187,059	448,941	1,378	22,056	427	26,006	1,819	227,305
1897.....	1,381	718,120	4,164	45,806	207,619	539,809	498	7,973	1,434	67,100	7,148	662,990
1898.....	1,739	904,280	5,145	56,599	217,556	587,401	840	14,280	699	38,870	4,606	533,233
1899.....	1,162	604,240	8,114	89,257	234,515	656,642	378	8,316	611	46,065	4,817	317,186

Year.	Lead. Ore. (c)		Lead. And Lead Alloys in Pigs.		Lead. Manufactures.		Lead. Oxide and Carbonate.		Mineral Paints.		Nickel, Alloys, and Manufactures of.	
1895.....	6,622	$211,904	2,153	$120,596	1,492	$125,716	747	$71,531	1,923	$42,313	2	$3,422
1896.....	4,731	151,392	1,419	85,140	1,441	141,019	489	47,823	2,412	53,055	35	34,229
1897.....	4,747	161,398	2,790	178,586	1,410	141,672	461	45,829	2,318	46,364	27	25,270
1898.....	4,492	157,220	5,870	410,886	1,764	189,362	414	41,413	2,884	57,684	29	28,586
1899.....	3,129	118,902	2,497	199,736	910	133,925	389	42,004	2,784	55,678	32	26,856

Year.	Potash, Ammonia, and Caustic Soda.		Quicksilver.		Salt, Sea and Rock.		Silver. Coin—Kg.		Silver. Unref'd in Bars, etc.—Kg.		Slag.	
1895.....	43	$3,125	213	$193,921	209,395	$460,669	21,989	$879,560	37,012	$836,494	2,469	$2,469
1896.....	88	7,453	155	139,590	171,741	360,656	28,377	1,135,080	26,854	644,496	4,753	4,753
1897.....	66	5,492	236	212,670	176,522	247,131	72,605	2,904,200	50,503	1,050,462	8,847	8,847
1898.....	85	11,718	244	234,432	126,867	197,913	8,241	329,640	68,607	1,427,026	6,861	6,861
1899.....	120	10,422	223	243,850	114,056	136,867	32,085	1,283,400	32,432	687,558	4,898	5,878

Year.	Sodium Salts. Carbonate.		Sodium Salts. Nitrate. (Crude.)		Sodium Salts. Refined. and Potassium Nitrate.		Stone. Alabaster, Crude.		Stone. Building Stone.	
1895.....	289	$5,206	27	$1,237	378	$26,488	176	$4,579	26,722	$89,905
1896.....	279	4,855	51	2,351	306	23,751	289	7,514	23,580	93,699
1897.....	275	5,225	151	6,506	344	26,482	269	6,989	36,229	117,705
1898.....	391	8,599	79	3,255	256	17,323	457	11,882	35,945	178,024
1899.....	438	9,638	136	5,725	124	8,823	714	18,577	53,904	259,519

Year.	Stone.—*Continued.* Marble, Crude.		Stone.—*Continued.* Marble and Alabaster.		Sulphur, Crude and Refined.		Tin. Pigs, Bars, etc.		Tin. Manufactures.	
1895.....	75,462	$905,544	58,371	$1,796,680	317,566	$4,128,359	7	$2,506	74	$29,822
1896.....	80,750	969,000	68,639	1,937,828	356,370	5,452,461	10	3,267	89	33,994
1897.....	83,081	996,972	62,750	1,864,862	358,932	6,819,713	29	9,699	109	41,452
1898.....	88,404	1,060,848	68,150	2,154,092	405,823	8,359,962	34	13,760	177	80,169
1899.....	98,485	1,181,820	84,104	1,768,193	424,018	8,692,375	69	47,124	176	114,864

Year.	Zinc. Ore.		Zinc. Oxide.		Zinc. Pigs and Scrap		Zinc. Manufactures.	
1895.....	111,227	$1,668,405	19	$1,930	4	$312	9	$2,165
1896.....	115,454	1,847,264	48	4,840	33	2,979	8	2,644
1897.....	133,125	2,130,000	189	18,910	309	27,783	63	13,142
1898.....	130,064	2,601,280	110	12,122	156	16,837	14	3,021
1899.....	140 107	3,362,568	123	14,820	227	29,977	21	4,249

(a) From the *Movimento Commerciale del Regno d'Italia.* (c) Includes argentiferous ore.

JAPAN.

THE mineral production of Japan is reported in the subjoined tables.

MINERAL PRODUCTION OF MINES IN JAPAN WORKED BY THE GOVERNMENT. (*a*)

(In metric tons.)

Fiscal Year.	Coal.	Copper.	Copper Sulphate.	Gold—Kg.	Iron—Pig.	Lead.	Silver.
1891–92	14,925	17	353	217·72	1,969	(*f*)	5,980·1
1892–93	21,945	275	63	273·77	1,417	70	8,584·1
1893–94	20,123	149	(*f*)	306·12	1,186	162	10,422·9
1894–95	22,506	277	(*f*)	372·15	1,210	50	10,991·1
1895–96	24,947	321	(*f*)	334·11	1,189	20	8,528·1

MINERAL PRODUCTION OF JAPANESE PRIVATE MINES. (*a*) (IN METRIC TONS.) (*b*)

Year.	Antimony.		Arsenic Kg.	Coal.	Copper.	Copperas	Gold.	Graphite.	Iron.	Lead.	Manganese Ore.
	Ore.	Metal.									
1895....	1,060·7	640·7	7,343·0	4,747,707	18,826	835·2	563·31	77	24,653	1,927·9	17,142
1896 (*g*).	827·6	517·3	6,043·4	5,019,689	20,114	868·6	963·69	215	27,420	1,957·7	17,967
1897 (*g*).	348·2	824·5	13,061·4	5,188,157	20,425	4·2	1,038·38	391	28,040	772·3	15,448
1898 (*g*).	1,006·1	233·2	7,141·0	6,696,033	21,060	20·1	1,161·21	347	23,652	1,705·5	11,517
1899 (*g*).	712·0	229·0	5,000·0	6,721,798	24,285	864·0	1,679·39	55	22,749	1,988·8	11,340

Year.	Ocher, Red.	Petroleum, Refined.	Quicksilver. Kg.	Silver. Kg.	Sulphur, Refined	Tin.
1895....	(*f*)	*h*26,965,764	481	63,824·1	15,557	48·3
1896 (*g*).	9·7	31,314	1,762	64,302·7	12,540	50·0
1897 (*g*).	35·7	34,743	2,682	54,387·4	13,606	47·7
1898 (*g*).	7·9	42,184	1,401	60,547·0	10,339	42·7
1899 (*g*).	28·0	*i*72,478,737	(*f*)	56,308·5	10,241	18·5

(*a*) From *Résumé Statistique de l'Empire du Japon*, Tokio, and special reports from the Japanese Government. The data contained in the table of production of the Government mines are nearly exact, but those contained in the table of private mines, being the figures furnished by the mine owners themselves, are only an approximation and considerably less than the actual figures. (*b*) In making the conversions from the Japanese units to metric tons, hektoliters and dollars, the following relations were employed: 1 kwan = .0037565 metric tons; 1 koku = 1·8039 hektoliters; 1 yen = $1; 1 kg. = 32·151 troy ounces. (*c*) Crude product. (*d*) Number of liters. (*f*) Not reported. (*g*) Includes production of Government mines. (*h*) Number of liters. (*i*) Liters of crude oil.

MINERAL IMPORTS OF JAPAN. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 kin = 0·00060104 metric tons; 1 yen = $1.)

Year.	Brass.				Coal.		Coke.		Copper.		
	Crude and Old.		Tubing.	Other M'f'res.					Sheet, Rod, and Old.		Tubes, and oth'r M'f'res.
1893.....	40	$23,071	$21,373	$2,420	7,564	$81,707	5,106	$29,325	3	$1,479	$20,566
1894.....	46	33,872	34,990	6,729	37,843	472,757	2,876	22,880	24	11,819	28,373
1895.....	68	42,968	107,569	30,811	70,034	853,080	10,065	90,669	72	37,457	118,909
1896.....	47	20,188	92,300	41,243	50,315	519,380	6,179	42,537	91	46,507	94,306
1897.....	20	10,496	89.170	41,092	70,229	578.570	7,600	56,154	76	43,899	201,833

Year.	Iron.									
	Pig.		Bar and Rod.		Plate and Sheet.		Various Manufactures. (*b*)		Railway Materials	Pipe and Tubes, and other M'f'res. (*c*)
1893.....	23,281	$446,477	22,630	$975,787	8,160	$456,644	17,654	$1,255,639	$147,641	$659,516
1894.....	36,642	743,553	28,098	1,339,034	14,778	889,185	21,334	1,765,302	881,805	1,237,516
1895.....	35,369	673,796	44,175	2,085,684	17,580	1,038,794	23,561	1,853,160	1,253,343	1,332,730
1896.....	39,028	739,556	50,464	2,359,705	27,642	1,659,417	36,306	2,641,885	1,280,480	1,534,259
1897.....	43,633	934,010	55,236	3,046,132	23,883	1,724,913	33,944	2,663,807	2,001,119	1,734,987

Year.	Iron and Steel for Rails.		Steel, including Wire and Wire Rope.		Steel Manufact'res	German Silver.		Kerosene. *Hektoliters.*		Lead.	
										Pig.	
1893.....	22,517	$677,108	4,524	$499,746	$202,301	45·6	$38,290	2,055,788	$4,401,041	1,768	$149,328
1894.....	34,657	1,209,205	3,383	462,619	297,876	42·8	41,909	2,257,067	5,135,332	1,638	177,638
1895.....	25,977	925.531	4,619	639,419	377,396	34·2	33,476	1,826,844	4,303,929	3,189	313,632
1896.....	65,387	2,595,450	6,810	1,022,108	446,275	44·4	39,830	2,213,073	6,331,036	2,411	257,383
1897.....	87,076	3,325,005	4,227	577,260	358,255	44·4	41,790	2,472,669	7,667,350	2,298	257,805

Year.	Lead—*Continued.*			Nickel.		Plumbago. Kg.		Quicksilver.		Tin.	
	Sheet and Tea.		Pipe.								
1893.....	1,779	$182,541	$5,428	42	$60,761	1,615	$232	76	$115,082	142	$90,578
1894.....	2,134	255,755	9,986	25	39,451	7,539	1,889	78	127,541	281	179,068
1895.....	1,664	224,546	40.310	29	37,731	10,718	2,160	75	141,302	323	191,936
1896.....	2,147	259,593	144,504	28	30,933	36.620	8,075	78	139,303	270	146,413
1897.....	1,972	269,638	76,910	44	50,321	155,595	15,413	80	156,527	264	145,174

Year.	Tin—Plate.		Yellow Metal.						Zinc.				All Other Metals and M'f'res
			Plates.		Rods.		M'nfactures.		Ingot.		Sheet and Old.		
1893.....	579	$56,267	120	$44,204	3	$1,196	$287		715	$95,106	2,350	$367,584	$188.147
1894.....	3,211	352,675	112	45,755	6	2.330	146		480	66,970	2,681	465,768	200,844
1895.....	3,009	314,044	303	124,461	14	5,851	1,494		993	134,614	3,441	555,695	441,188
1896.....	2,626	251,344	172	74,940	24	9,403	375		1,078	144,240	2,991	512,241	1.773,014
1897.....	5,677	559,654	116	51,419	13	6,334	4,703		836	127,703	4,164	799,930	1,053,682

(*a*) From data specially furnished THE MINERAL INDUSTRY by the Japanese Government. (*b*) Includes old iron, hoop and band, roofing or corrugated and galvanized, nails, and galvanized telegraph wire, iron wire and wire nails (old), and other manufactures. (*c*) Includes also anchors and chain cables, screws, bolts, nuts, etc., and other iron ware.

MINERAL EXPORTS OF JAPAN. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 kin = 0·00060104 metric tons; 1 yen = $1.)

Year.	Antimony.			Brass.			Bronze.			Coal.			
	Metal.		M'factures.	Wire.		M'factures.	Ingot.		M'factures.	For Ships' Use.		Dust.	
1893..	1,316	$183,854	$75,678	151	$52,029	$22,819	416	$91,115	$190,501	417,229	$1,529,070	269,328	$641,758
1894..	1,612	254,261	72,366	232	85,850	43,690	306	70,609	183,688	442,596	1,904,156	238,100	757,039
1895..	1,450	289,935	130,277	177	79,381	44,533	104	27,602	229,291	476,247	2,195,678	283,962	982,710
1896..	624	83,806	104,010	222	108,612	35,526	54	14,570	180,318	588,963	2,636,324	299,102	930,704
1897..	1,577	267,548	63,331	147	72,414	66,388	27	8,373	183,022	582,031	3,229,024	188,132	859,514

Year.	Coal—*Continued.*		Coke.		Copper.							
	Other Kinds.				Ingot.		Old.		Refined.		Slab.	
1893....	842,942	$2,647,084	1,143	$7,219	7,102	$2,033,820	22·0	$5,480	5,115	$1,597,926	3,110	$931,802
1894....	1,047,651	3,917,266	1,197	7,763	5,797	1,799,435	7·0	1,868	5,820	1,945,456	3,651	1,155,863
1895....	1,114,123	4,426,400	4,382	37,487	3,942	1,340,584	0·09	32	5,527	2,123,707	5,067	1,693,377
1896....	1,350,458	5,312,227	3,399	29,114	6,756	2,423,116	0·32	113	6,134	2,461,039	1,644	594,448
1897....	1,366,498	7,457,262	2,950	45,384	2,741	1,075,945	6·81	2,077	6,172	2,680,807	5,045	2,017,947

Year.	Copper—*Continued.*			Iron Wares.	Other Metal Wares.	Manganese Ore.		Sulphur.		Other Mineral Products.	Total.
	Wire.		M'factures.								
1893....	$71	$26,169	$71,984	42,555	176,254	18,689	$212,884	10,441	$238,832	$4,202	10,804,023
1894....	69	26,975	134,970	62,142	179,894	17,634	198,810	12,683	244,542	2,245	13,059,614
1895....	69	31,145	101,342	96,875	314,530	16,496	196,599	15,894	296,136	660	14,651,701
1896....	72	33,717	135,079	105,481	358,126	20,986	274,434	12,325	308,588	1,920	16,161,052
1897....	93	46,947	223,234	178,037	485,862	14,665	205,318	9,209	321,341	1,396	19,525,094

(*a*) From data furnished to THE MINERAL INDUSTRY by the Japanese Government.

MEXICO.

THE Mexican Government collects no statistics of production; those compiled by THE MINERAL INDUSTRY, which represent all the important substances, will be found under the respective captions "Lead," "Copper," "Coal," etc.

MINERAL EXPORTS OF MEXICO. (*a*) (IN METRIC TONS AND MEXICAN DOLLARS.) (*e*)

Year.	Antimony Ore.		Asphalt.		Building Material.		Coal.		Copper. Ore.		Copper. Ingot.	
1896	3,231	$32,093	17	$2,134	9,934	$45,418	75,541	$312,738	144	$5,210	20,659	$4,008,404
1897	5,873	71,835	10	282	1,808	7,858	105,298	434,624	1,094	176,391	16,858	3,329,331
1898	5,932	98,815	(*b*)		597	3,561	118,553	486,596	13,146	3,738,738	10,362	2,314,790
1899	10,382	115,292	47	1,623	956	5,923	113,192	453,303	223	54,828	25,293	7,915,827
1900	2,313	23,319	627	12,845	2,623	9,804	38,676	157,282	408	49,736	27,970	9,445,498

Year.	Gold. Coin.	Gold. Ore.	Gold. Bullion.	Gold. Cyanide	Gold. Sulphide.	Graphite.		Gypsum.	
1896	$261,078	$206,874	$5,533,789	$161,784	$44,890	795	$7,290	2,050	$10,250
1897	202,223	365,226	6,220,765	226,986	33,916	759	6,698	2,095	7,775
1898	(*b*)	1,037,202	6,493,735	294,730	64,061	(*b*)		1,650	8,250
1899	183,474	335,849	7,017,286	115,961	266,782	2,305	22,847	1,050	5,250
1900	192,456	306,392	7,435,864	128,675	177,193	2,561	25,650	1,600	8,000

Year.	Iron Ore.		Jewels and Precious Stones. *Grams.*		Lead. Ore.		Lead. Base Bullion.		Marble.		Pearls—*Carats*	
1896	1	$30	1,357	$1,113	167·0	$4,820	48,663	$1,340,785	2,258	$210,836	225	$5,500
1897	(*b*)		3,880	5,638	1·9	87	60,029	3,006,821	2,176	185,004	1,420	6,000
1898	21	208	11,241	27,867	(*b*)		60,918	3,291,014	469	46,724	*d*327	3,500
1899	(*b*)		2,489	801	1·0	175	67,441	3,885,747	370	33,220		17,000
1900	(*b*)		1,447	875	468·0	11,425	74,944	4,278,608	1,030	108,759	(*b*)	

Year.	Quicksilver. Kg.		Silver. Coin.	Silver. Ore.	Silver. Slag.	Silver. Bullion.	Silver. Sulphide.	Silver. Cyanide	Tin.	
1896	450	$770	$18,737,331	$9,971,053	$64,121	$28,565,843	$1,495,306	$38,049	5·0	$2,265
1897	1,845	3,150	21,925,347	11,401,176	39,800	35,775,125	1,663,581	123,246	0·6	40
1898	(*b*)		(*b*)	11,048,358	46,488	37,137,599	1,663,501	257,342	(*b*)	
1899	(*b*)		5,580,834	10,766,099	4,810	37,585,911	1,929,085	76,942		
1900	(*b*)		22,679,655	12,495,524	87,883	41,468,745	1,893,646	67,607	.096	43

(*a*) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. Additional exports in 1900: zinc, 63·8 metric tons, $6,384; zinc ore, 1,027 tons, $9,385; salt, 1,518 tons, $4.151; 1898: salt, 1,533 metric tons, $13,449; zinc ore, 1,001 metric tons, $10,016. (*b*) Not reported. (*d*) There was also exported pearls, 42 g., $1,000. (*e*) The average value of the Mexican dollar in New York was in 1896, $0·5228; in 1897, $0·4671: in 1898, $0·4641; in 1899, $0·473; in 1900, $0·509.

NOTE.—There was exported of zinc in 1900, 638 metric tons, worth $6,384; of zinc ore, 1,027 tons, worth $9,385; of salt, 1,518 tons, worth $4,151. Of minerals classed in the *Boletin de Estadistica Fiscal* as "other mineral products not specified," there were exported 749 tons, valued at $5,347.

NORWAY.

THE official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone=27 cents.)

Year.	Apatite. (*b*)		Cobalt Ore.		Copper Ore.		Feldspar. (*b*)		Iron Ore.	
1894.....	2,086	$36,720	89	$8,100	20,226	$192,240	7,836	$35,910	(*c*)	
1895.....	1,601	23,760	45	4,050	21,869	218,835	9,780	44,901	1,250	$2,949
1896.....	1,106	17,280	29	2,700	29,910	306,747	12,222	54,540	2,000	3,780
1897.....	872	12,960	24	2,700	27,606	308,907	17,392	79,650	3,627	5,670
1898.....	3,593	53,352	21	2,160	37,047	425,466	11,355	49,059	4,425	7,992

Year.	Nickel Ore.		Pyrites, Iron and Copper.		Rutile. Kg.		Silver Ore and Native Silver.		Zinc and Lead Ore.	
1894.....	2,355	$5,400	70,859	$268,110	19,000	$4,050	750	$100,710	200	$1,890
1895.....	494	1,080	49,005	194,400	28,000	8,100	490	95,850	(*c*)	
1896.....	315		60,507	261,900	30,000	9,720	527	108,000	450	3,645
1897.....	*Nil.*		94,484	390,150	32,000	5,400	642	103,950	908	7,290
1898.....	*Nil.*		89,763	386,586	35,000	5,940	497	89,640	320	2,592

Metallurgical Production.

Year.	Cobalt—Kg.		Copper and Copper in Mattes.		Gold.	Iron, Pig and Cast.		Iron, Bar and Steel.		Nickel.		Silver—Kg.	
1894.....	(*c*)		907	$178,200	$1,080	287	$3,240	433	$19,980	103	$63,450	4,760	$102,600
1895.....	2,500	$8,100	958	184,950	2,160	348	3,942	379	19,440	17	10,530	5,000	105,300
1896.....	*Nil.*		1,067	227,610	9,450	335	3,780	400	21,060	16	8,100	4,664	129,600
1897.....	*Nil.*		1,064	252,450	675	417	4,590	452	23,760	*Nil.*		5,372	101,790
1898.....	*Nil.*		941	238,680	1,539	231	2,700	379	20,520	*Nil.*		4,802	95,850

(*a*) From *Tabeller vedkommende Norges Bergvaerksdrift, Statistisk Aarbog for Kongeriget Norge*, 1896, and from *Meddeleser fra Det Statistiske Centralbureau*, No. 7, 1899, published by Det Statistike Centralbureau, Christiania. There were also produced in 1894, 7,000 kg. of molybdenite, value $3,780, and in 1895, molybdenite 4,000 kg., $2,160, and chrome ore 190 metric tons, $2,295. (*b*) Export returns, which approximately represent the production. (*c*) Not reported.

MINERAL IMPORTS OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Borax and Boric Acid. Kg.		Cement and Hydraulic Lime. *Hektoliters.*		Coal, Coke, and Cinders—*Hektoliters.*		Copper and Brass. Plates, Bolts, and Bars.		Copper and Brass. Wares.		Glass and Glassware.	
1895..	40,154	$5,427	80,861	$109,161	14,012,194	$3,783,294	1,262	$323,595	417	$293,841	3,343	$407,592
1896..	38,305	4,671	16,028	137,052	14,201,090	3,642,570	1,074	290,061	479	330,696	3,729	449,577
1897..	44,495	4,941	18,734	174,258	15,374,572	4,234,167	1,140	307,827	591	495,802	4,262	548,802
1898..	71,590	6,804	25,403	239,057	15,409,902	4,659,957	1,064	316,089	807	643,248	3,905	411,615
1899 .	46,404	3,753	*d* 38,251	385,857	*d* 1,478,080	6,485,076	1,000	391,473	1,120	928,071	3,229	412,344

Year.	Iron. Pig and Cast.		Bars, Hoops, Ships' Knees, etc.		Ships' Anchors and Cables.		Rails.		Nails, Spikes, Bolts, Screws, etc.		Other Manufactures of Iron.	
1895.....	19,654	$254,718	24,985	$790,695	1,152	$71,523	10,337	$279,099	1,796	$96,984	31,387	$2,563,218
1896.....	20,201	252,801	26,552	890,433	1,090	67,689	4,315	116,505	1,760	104,544	34,323	2,762,208
1897.....	21,606	289,791	29,038	1,013,364	1,367	87,237	7,637	247,428	2,097	153,738	47,494	4,590,918
1898.....	23,106	339,579	26,203	951,345	1,485	105,057	10,327	362,475	2,087	159,921	62,197	5,450,868
1899.....	21,445	395,550	25,379	1,099,494	1,394	104,868	8,137	281,205	1,529	130,842	78,827	7,091,946

Year.	Steel.		Locomotives and Machines.	Lead, in Pigs and Sheets.		Lead White and Zinc Oxide.		Paraffin Oil, Petroleum, etc.		Potash.	
1895.....	3,654	$197,289	$1,263,438	657	$38,988	1,068	$89,424	27,978	$982,044	562	$47,034
1896.....	2,754	156,141	1,895,994	653	40,527	1,192	99,738	35,823	1,160,676	945	79,083
1897.....	4,350	246,645	2,058,885	848	54,972	1,119	93,636	39,810	1,021,113	919	76,928
1898.....	2,428	144,234	2,437,371	732	51,408	1,491	140,886	36,504	887,031	754	63,099
1899.....	2,652	164,673	2,893,509	869	66,744	1,296	139,995	42,182	1,138,914	802	71,496

Year.	Salt. *Hektoliters.*		Saltpeter.		Soda.		Sulphur. (*b*)		Tin, in Blocks, etc.		Zinc, in Plates, Bars, etc.	
1895.....	1,239,334	$468,477	227	$17,199	5,234	$56,511	7,271	$176,688	99	$34,884	978	$87,129
1896.....	1,179,198	429,813	308	23,247	5,156	55,674	9,347	227,124	142	49,788	1,101	107,055
1897.....	1,645,716	630,963	277	15,708	5,492	59,319	10,701	260,037	236	82,917	1,102	107,082
1898.....	1,273,405	488,214	477	34,776	4,823	52,083	9,589	258,903	257	98,307	1,370	162,729
1899.....	*d*134,583	508,734	278	20,250	4,555	61,506	10,734	289,818	546	314,226	1,569	202,905

MINERAL EXPORTS OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Apatite.		Clay Products. Bricks. *Thousands.*		Clay Products. Earthenware.		Cobalt Ore—Kg.		Copper. Ore.		Copper. Ingot.	
1895.....	1,601	$23,760	5,016	$20,304	286	$30,888	30,000	$8,910	20,283	$219,051	705	$142,722
1896.....	1,160	17,226	10,008	48,654	365	39,420	33,800	8,208	30,367	409,941	565	129,573
1897.....	872	12,960	11,711	59,454	260	27,378	45,000	9,720	15,111	204,012	552	131,031
1898.....	3,593	53,352	15,534	69,677	2	243	25,000	5,400	13,587	183,411	444	113,886
1899.....	1,500	22,275	11,949	56,457	1	27	*Nil.*		7,198	116,613	747	242,001

Year.	Copper—*Con.* Old Metal.		Feldspar.		Glassware.		Iodine—Kg.		Iron. Ore.		Iron. Pig and Old.	
1895.....	810	$109,404	9,780	$44,901	1,153	$89,721	2,683	$15,201	1,545	$2,916	8,188	$92,826
1896.....	712	86,454	12,223	54,459	1,231	94,581	1,959	11,097	2,051	3,888	5,493	62,289
1897.....	670	81,459	17,392	79,839	1,432	78,894	2,395	11,151	4,242	8,019	4,631	53,136
1898.....	1,206	156,249	11,355	49,059	841	31,212	5,474	29,565	4,601	8,694	3,844	44,118
1899.....	1,038	224,316	19,260	78,003	840	26,838	16,180	87,372	12,517	23,652	6,085	69,822

Year.	Iron.—*Continued.* Bars and Hoops.		Iron.—*Continued.* Nails and Spikes.		Steel.		Machinery.		Nickel Ore. Kg.	
1895.....	19	$702	10,408	$781,758	133	$7,884	1,100	$297,055	(*c*)	
1896.....	12	459	10,664	747,819	132	7,830	714	192,915	(*c*)	
1897.....	56	2,376	9,097	636,552	167	9,936	992	267,840	(*c*)	
1898.....	25	1,134	7,270	489,402	158	9,369	507	136,971	30,000	$135
1899.....	337	16,848	6,089	463,833	377	22,410	464	125,928	63,200	351

Year.	Pyrites.		Silver Ore—Kg.		Stone, Ashlar.		Whetstones.	
1895.....	39,710	$128,655	136,800	$5 535	54,888	$237,114	169	$11,421
1896.....	41,062	140,265	173,500	7,261	66,233	312,957	205	13,851
1897.....	70,552	238,113	118,900	3,861	74,492	367,065	112	7,587
1898.....	67,502	236,925	79,000	2,565	98,692	546,264	137	9,261
1899.....	83,912	294,543	14,160	972	104,933	566,649	170	11,475

(*a*) From *Statistisk Aarbog for Kongeriget Norge.* (*b*) Inclusive of flowers of sulphur. (*c*) Not reported (*d*) Metric tons.

PORTUGAL.

THE mineral statistics of Portugal are summarized in the subjoined table, for which we are indebted to the courtesy of Sehnor Severiano Augusto da Fonseca Monteiro, chief of the Reparticao de Minas, Ministerio das Obras Publicas of Portugal.

The statistics of mineral production in Portugal in years prior to 1895 may be found in THE MINERAL INDUSTRY, Vol. II. and Vol. VI. It will be observed that the mineral industry of Portugal has not yet attained much importance, the output of copper and copper ore forming the chief part of the total. This is principally the production of Mason & Barry Co., Ltd.

MINERAL PRODUCTION OF PORTUGAL. (*a*) (IN METRIC TONS AND DOLLARS; 1 milreis = $1·08.)

Year.	Antimony Ore.		Arsenic.		Coal. (Anthracite.) (*b*)		Coal. (Lignite.) (*b*)		Copper Ore.		Copper. (Cement.)	
1895..	753	$36,589	(*c*)		8,787	$35,820	10,309	$22,090	202	$3,822	5,055	$498,783
1896..	595	28,917	(*c*)		8,743	17,944	8,000	18,306	436	10,535	3,453	467,897
1897..	418	28,063	524	$20,369	7,996	32,816	9,342	24,215	241	4,496	3,304	408,262
1898..	245	6,736	751	44,704	10,250	37,032	12,201	52,056	200	12,799	3,149	533,581
1899..	59	2,123	1,083	61.356	11,930	46,398	10,269	41,161	408	29,920	2,521	520,099

Year.	Copper Pyrites.		Copper Pyrites. (Dressed.)		Gold Ore.		Iron Ore.		Lead Ore. (Galena.)		Lead Ore. (Argentiferous.)	
1895.....	32,814	$99,020	162,499	$227,025	222·0	$3,159	(*c*)		1,346	$27,620	25	$513
1896.....	43.665	139,525	163,775	224,634	(*c*)		(*c*)		1,333	30,236	(*c*)	
1897.....	66,473	178,014	210,265	287,254	17·0	12,085	(*c*)		2,180	56,300	(*c*)	
1898.....	54,368	133,899	248,218	366,258	6·8	4,687	2,519	$3,265	3,242	100,480	(*c*)	
1899.....	71,576	358,128	275,658	378,018	13·0	78	15,078	25,564	3,468	104,627	(*c*)	

Year.	Manganese Ore.		Silver—Kg.		Tin Ore.		Tungsten Ore.	
1895.....	1,240	$8,250	(*c*)		3	$528	12·4	$2,786
1896.....	1,494	14,679	(*c*)		6	756	14·0	3,640
1897.....	1,652	11,596	79	$2,042	*d* 9	2,550	29·4	7,263
1898.....	907	2,595	119	2.362	102	23.278	59·3	16,714
1899.....	2,949	21,484	(*c*)		30	9,418	55·0	13,513

(*a*) From a report specially furnished THE MINERAL INDUSTRY by Senhor Severiano Augusto da Fonseca Monteiro, Chief of the Department of Mines of the Ministerio das Obras Publicas. (*b*) Consumed in the country. (*c*) No report, probably none. (*d*) Includes metallic tin and cassiterite.

RUSSIA.

THE official statistics of mineral production, imports and exports, are given in the subjoined tables. The Russian official statistics of production are somewhat tardy in appearance, the latest being those for 1897. Statistics of the production of gold, silver, copper, zinc, petroleum, quicksilver and pig iron for 1898 and 1899 have been reported, however, especially to THE MINERAL INDUSTRY, and will be found under their respective captions elsewhere in this volume.

MINERAL PRODUCTION OF RUSSIA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Asbestos.		Asphaltum.		Chrome Iron Ore.		Coal.		Cobalt Glance.	Copper.		Gold—Kg.	
1893	1,059	$6,836	14,925	$114,800	14,585	$35,101	7,613,724	$9,225,200	3	5,463	$1,586,526	44,865	$21,869,708
1894	570	3,400	16,054	176,422	7,537	18,760	8,762,340	11,473,600	9	5,419	1,320,800	42,932	20,985,200
1895	1,131	6,800	18,783	143,542	21,013	51,316	9,099,476	12,150,400	3	5,854	1,429,516	41,097	18,812,993
1896	1,274	7,666	22,192	145,428	6,682	16,316	9,377,551	13,198,424	4	5,832	1,424,076	37,199	16,845,122
1897	1,022	37,444	22,222	184,616	13,433	32,804	11,203,738	15,578,184	3	6,940	1,961,539	38,198	17,255,532

Year.	Graphite.		Iron, Cast.		Kaolin.		Lead.		Manganese Ore.		Petroleum.		Phosphorites.	
1893	311	$15,200	1,148,902	$19,100,000	3,197	$12,848	844	$46,922	268,621	$669,100	5,790,692	$2,781,851	13,706	$36,994
1894	...	...	1,332,465	22,200,000	7,742	30,400	743	36,000	243,469	490,800	5,161,552	3,916,800	14,072	31,680
1895	...	...	1,452,337	22,312,800	25,330	101,200	412	20,000	203,081	388,522	7,056,330	11,490,800	6,327	18,682
1896	...	...	1,620,812	25,315,436	6,099	24,575	262	12,775	208,025	398,000	7,105,768	12,588,860	3,776	11,065
1897	98	...	1,880,135	31,636,289	5,036	20,244	450	25,285	370,190	1,102,124	7,831,254	14,623,058	5,917	22,132

Year.	Platinum—Kg.		Pyrites.		Quicksilver		Salt.		Silver—Kg.		Sodium Sulphate.	
1893	5,094	$917,231	16,271	$51,200	201	$220,484	1,351,056	$2,224,234	9,500	$276,696	5,037	$36,754
1894	5,202	890,400	19,801	48,000	196	153,200	1,354,218	1,723,200	7,813	227,200	4,014	28,800
1895	4,406	883,960	11,042	31,200	434	371,000	1,540,194	2,383,743	7,878	239,088	4,207	15,612
1896	4,930	1,083,600	11,550	32,435	491	432,058	1,346,247	2,079,388	7,813	235,172	5,198	9,600
1897	5,602	1,238,040	19,380	54,426	616	541,440	1,551,894	2,711,077	4,783	172,581	7,230	13,352

Year.	Sulphur.		Tin.		Zinc.	
1893	589	$7,200	7	$2,501	4,501	$428,604
1894	1	18	4	1,440	5,014	367,336
1895	190	2,316	8	5,068	5,029	360,000
1896	437	5,339	2	476	6,257	458,369
1897	574	11,917	2	476	5,868	549,114

(*a*) From the Russian official mining report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennostye Rossie v Zavodskom Godu," St. Petersburg. (*b*) In the Russian reports the quantities are stated in poods and the values in silver rubles. In making the reductions the following relations were employed: 1 pood = ·01638 metric ton; 1 silver ruble = 40 cents.

MINERAL IMPORTS OF RUSSIA. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 pood = ·01638 metric ton; 1 ruble = 40 cents.)

Year.	Asbestos.		Asbestos Manufactures.		Asphalt Rock.		Barytes and Witherite.		Clay, Bauxite and Talc.		Coal.		Coke.	
1893..	38	$1,060	108	$19,924	349	$2,600	4,083	$33,289	52,593	$322,717	1,715,258	$4,776,731	289,978	$968,914
1894..	49	5,819	197	34,192	458	5,654	6,355	40,797	64,428	418,048	1,973,516	5,361,537	290.822	925,762
1895..	107	8,186	241	58,888	566	3,465	7,703	65,297	55,212	327,838	1,934,280	5,293,392	310,113	961,475
1896..	137	5,510	378	85,432	947	8,183	7,053	56,528	*e*64,135	419,564	1,979,649	5,439,378	364,427	1,146,668
1897..	122	6,593	514	98,829	737	7,392	7,826	73,030	66,980	346,115	2,122,361	4,183,082	399,909	1,675,072

Year.	Copper and Alloys.		Copper and Brass Manufactures.		Glauber Salts.		Gold Bars and Coin—Kg.		Iron.			
									Castings.		Pig.	
1893..	13,814	$4,047,212	*d*1,480	$882,232	2,649	$88,728	17,019	$5,278,049	3,031	$326,122	160,507	$2,757,083
1894..	8,033	3,352,393	*d*1,558	935,503	3,644	99,052	(*b*)		4,669	463,440	144,641	2,299,316
1895..	11,679	2,725,159	*d*1,598	1,045,372	3,303	79,883	(*b*)		4,799	602,644	127,202	2,227,129
1896..	15,726	3,997,911	*d*1,601	1,100,247	3,619	78,067	(*b*)		7,810	759,814	75,317	1,454,885
1897..	13,590	2,818,348	*d*1,947	1,159,106	4,550	90,664	(*b*)		10,280	876,949	98,409	1,357,485

Year.	Iron—*Continued.*								Lead.		Magnesite.	
	Tin Plate.		All Other.		Iron and Steel Manufactures.		Steel, All Kinds.					
1893....	22,132	$2,309,751	87,449	$4,363,469	(*b*)	$2,121,317	35,130	$2,151,926	18,712	$1,481,455	720	$17,056
1894....	20,790	1,491,923	188,418	8,689,817	19,171	3,143,306	38,805	3,782,477	11,979	1,620,034	276	5,057
1895....	30,489	2,194,164	218,985	10,182,897	20,214	3,205,413	52,523	3,003,229	29,556	1,820,843	1,127	20,094
1896....	23,144	1,707,033	274,288	12,787,963	26,989	3,771,949	72,509	3,931,378	31,388	1,720,550	1,434	5,510
1897....	2,717	146,557	308,345	11,688,733	26,588	3,636,605	87,413	4,201,118	31,236	1,496,581	2,395	23,418

Year.	Mica—Kg.		Naphtha, Crude.	Oil, Kerosene, Benzine, etc.		Ores, Except Graphite.		Other Metals, Manufactures of.		Phosphorites.		Pyrites.	
1893..	377	$348	$11	362	$28,664	1,022	$2,261	479	$106,241	14,815	$156,032	11,594	$215,734
1894..	2,162	529	10	465	31,249	(*b*)		1,573	982,444	27,006	356,372	36,950	279,076
1895..	2,407	917	(*b*)	537	44,494	1,534	19,800	12,370	3,374,097	(*b*)		22,410	241,393
1896..	3,047	1,301	8	120	7,084	21,468	58,003	4,853	1,987,570	18,156	176,868	20.631	149,582
1897..	(*b*)		48	1,811	57,961	21,887	59,619			(*b*)		33,733	157,336

Year.	Quicksilver.		Salt.		Saltpeter, Chile.		Salts, Stassfurt.		Silver—Kg.		Strontianite and Celestite.		Sulphur.	
1893..	10	$7,312	6,914	$40,946	8,487	$183,537	4,746	$37,528	428.107	$7,249,674	404	$18,814	23,569	$407,818
1894..	11	5,932	10,433	65,692	14,083	357,504	5,190	56,308	(*b*)		575	24,986	19,893	384,752
1895..	7	6,986	10,332	57,400	12,315	294,788	4,463	41,038	(*b*)		34	1,118	19,525	233,233
1896..	15	10,499	10,213	62,492	18,337	414,770	5,553	51,250	(*b*)		216	12,690	19,532	227,428
1897..	10	6,267	8,467	46,710	12,938	241,360	5,491	40,322	(*b*)		881	10,676	20,715	258,160

Year.	Tar, Asphaltic Mastic, etc.		Tin.		Zinc. Ingot and Sheet.	
1893.....	52,593	$322,717	4,007	$868,763	8,146	$909,670
1894.....	3,021	74.075	3,386	688,333	8,289	879,164
1895.....	2.721	77,668	3,417	705,597	9,194	962,106
1896.....	3,011	89,810	4,481	841,436	7,516	766,164
1897.....	6,841	116,869	3,938	808,947	9,546	640,755

(*a*) From the Russian official report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennostye Rossie v Zavodskom Godu," St. Petersburg. (*b*) Not reported. (*d*) Includes bronze manufactures. (*e*) Represents clay used for furnaces.

MINERAL EXPORTS OF RUSSIA. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 pood = ·01638 metric ton; 1 ruble = 40 cents.)

Year.	Bronze and Manufactures.		Clay, Bauxite and Talc.		Coal.		Copper and Alloys.		Copper and Brass Manufactures.		Gold Coin and Bullion—Kg.	
1893..	(*f*)	$7,042	409	$1,454	8,206	$27,035	49	$14,848	267	$136,939	296·5	$92,579
1894..	(*f*)		387	(*f*)	7,889	24,174	51	15,912	259	19,983	229·0	68,578
1895..	(*f*)	10,290	166	1,227	7,544	20,870	47	12,154		86,146	(*f*)	
1896..	(*f*)	5,709	1,522	3,542	16,566	25,130	31	8,229	129	62,064	(*f*)	
1897..	(*f*)		2,050	4,412	33,142	51,879	29	9,353		120,460	(*f*)	

Year.	Iron.						Manganese Ore.		Metals, Other		Naphtha.			
	Castings.		Pig.		All Other.						Crude.		Residuum.	
1893..	481	$52,253	234	$6,340	5,189	$252,647	129,016	$1,512,538	(f)		4,866	$12,745	41,759	$306,944
1894..	822	135,231	224	6,023	5,497	212,173	125,167	1,251,326	247	$36,839	9,574	22,840	53,254	392,590
1895..	298	30,070	192	7,040	2,312	117,207	146,840	1,194,035	202	30,308	9,266	22,856	54,658	403,076
1896..	439	39,011	184	7,950	4,534	239,499	165,600	1,215,399	127	12,150	2,942	40,514	54,451	449,876
1897..	547	60,019	238	6,708	4,150	184,139	187,396	1,138,824	(f)		9,605	47,576	62,945	565,210

Year.	Oil, Kerosene, Benzine, etc.		Ores of Metals and Minerals, Except Graphite.		Paraffin.		Phosphorites.		Platinum, Crude—Kg.		Quicksilver.	
1893..	790,007	$8,416,610	66	$1,189	(f)		7,629	$109,553	6,000	$447,685	266	$383,317
1894..	819,485	6,778,882	1,183	19,553	(f)		8,892	28,800	2,000	270,190	132	153,111
1895..	709,406	5,642,097	432	10,260	b	$370	10,918	134,886	(f)		140	164,398
1896..	845,751	8,129,730	20,626	40,071	b93	3,746	8,840	107,898	4,700	777,900	430	383,629
1897..	917,216	9,507,619	16,890	40,874	b740	15,516	2,917	36,369	4,767	700,780	643	575,409

Year.	Salt.		Silver—Kg.		Slags.		Steel.		Zinc.			
									Ore.		Ingot and Sheet.	
1893..	9,774	$34,484	103,037	$1,754,856	3,967	$12,745	760	$59,534	248	$3,708	248·0	$1,219
1894..	6,457	21,817	167,010	2,858,582	8,994	15,776	283	24,022	40	1,414	27·0	2,963
1895..	7,023	17,790	(e)		5,173	11,334	167	14,855	208	2,820	1·0	446
1896..	6,814	16,461	(e)		5,606	11,274	173	15,338	194	4,390	3·5	264
1897..	9,022	21,668	(e)		9,702	22,447	160	17,579			12·4	1,552

(a) From the Russian official report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennosty Rossie v Zavodskom Godu," St. Petersburg. (b) Includes vaseline. (e) Included under precious metals. (f) Not reported.

SPAIN.

THE official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL AND METALLURGICAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Aluminous Earths.		Antimony Ore.		Arsenic Sulphide.		Asphalt, Refined.		Asphalt Rock.		Barytes.		Cement, Hydraulic.	
1895....	240	$1,198	44	$700	184	$18,390	790	$10,275	790	$1,581	494	$2,255	149,197	$324,214
1896....	320	1,600	54	1,385	271	27,100	1,285	16,705	1,117	2,234	345	1,720	130,738	281,144
1897....	409	2,046	354	6,718	244	29,256	1,878	22,532	1,656	3,312	429	2,449	159,439	325,202
1898....	505	2,525	130	2,149	111	13,320	2,354	29,626	2,383	4,772	364	2,074	164,862	358,501
1899....	685	3,225	50	1,560	101	12,156	2,646	34,088	2,542	5,144	887	3,071	165,645	363,441

Year.	Coal.								Cobalt Ore.		Coke.	
	Anthracite.		Bituminous.		Briquettes.		Lignite.					
1895.....	10	$10	1,739,075	$2,648,367	342,985	$1,370,987	44,708	$58,333	7	$84	249,058	$1,046,033
1896.....	14.895	26,788	1,852,947	2,806,654	343,432	1,373,061	55,413	60,261	18	1,800	288,523	1,202,716
1897.....	8,758	15,745	2,010,960	3,409,636	332,272	1,318,532	54,232	54,027	13	3,400	755,394	3,167,416
1898.....	20.105	36,190	2,414,127	4,147,333	369,418	1,277,425	66,422	93,310	(*b*)		768,151	3,211,300
1899.....	34.842	98,256	2,565,437	4,780,114	348,838	1,216,562	70,901	78,630	(*b*)		341,443	1,311,816

Year.	Copper.						Copper Ore.					
	Fine.		In Matte.		In Precipitate.		Argentiferous.		Copper and Cobalt.		Pyrites.	
1895.....	7	$1,520	5,756	$345,385	31,725	$4,439,889	(*b*)		410	$6,560	2,701,661	$2,829,422
1896.....	6	1,200	16,378	982,702	29,873	4,155,204	*c*157,365	$146,596	992	23,808	2,200,919	2,205,843
1897.....	7	1,400	16,120	967,210	29,052	4,138,725	*c*18,488	35,922	(*b*)		2,161,182	2,124,803
1898.....	593	118,623	16,024	961,438	29,703	4,158,418	203	1,831	(*b*)		2,299,444	2,735,261
1899.....	4	921	15,775	946,506	41,927	5,859,545	(*b*)		(*b*)		2,443,044	2,985,001

Year.	Fluorspar.		Gold and Silver Ore.		Graphite.		Iron and Steel.					
							Forged Iron.		Pig Iron.		Steel.	
1895....	27	$405	918	$4,593	(*b*)		48,462	$2,053,822	179,752	$2,575,065	56,801	$2,189,222
1896....	3	45	854	3,056	(*b*)		53,793	2,224,443	100,786	1,481,162	68,126	2,666,843
1897....	2	36	2,456	9,873	(*b*)		80,894	3,190,139	146,940	2,267,403	66,007	2,873,930
1898....	5	75	555	2,165	10	$18	65,900	2,826,743	113,492	2,059,232	50,362	2,332,019
1899....	310	750	*f*1,110	7,060	(*b*)		40,332	2,120,514	113,071	2,011,536	112,982	4,138,317

Year.	Iron Ore.				Kaolin. (China Clay.)		Lead.			
	Argentiferous.		Non-Argentiferous.				Argentiferous.		Non-Argentiferous.	
1895.....	572	$572	5,514,339	$4,183,059	836	$1,579	83,978	$6,916,320	76,808	$3,637,932
1896.....	3,581	3,581	6,762,582	5,013,404	1,240	2,446	84,802	5,808,313	82,215	4,386,544
1897.....	5,559	19,347	7,419,768	5,457,327	6,294	6,717	91,258	6,312,109	75,112	4,343,187
1898.....	24,190	68,216	7,197,047	6,232,484	5,445	5,518	88,981	6,026,450	78,370	5,188,394
1899.....	17,139	26,051	9,397,733	8,600,211	2,790	7,540	70,874	4,895,323	91,739	7,450,466

Year.	Lead Ore.				Manganese Ore.		Mineral Waters.		Nickel Ore.	
	Argentiferous.		Non-Argentiferous.							
1895	181,433	$5,042,288	124,195	$2,052,312	10,162	$17,043	15,193,865	$75,538	(b)	
1896	182,565	6,121,173	104,160	1,884,807	38,265	53,732	15,738,142	92,485	100	$880
1897	186,692	6,735,013	110,469	2,058,611	100,566	136,250	16,180,585	115,874	(b)	
1898	244,068	8,023,772	150,472	4,948,056	102,228	343,045	15,610,222	122,265	(b)	
1899	184,906	7,624,507	123,753	4,774,408	104,974	353,088	19,770,137	113,907	(b)	

Year.	Ocher.		Phosphorites.		Pyrites.		Pyrites. (Arsenical)		Quicksilver.		Quicksilver Ore.	
1895	203	$787	1,040	$2,081	60,267	$30,335	(b)		1,506	$1,343,417	33,792	$1,248,815
1896	212	850	770	3,080	100,000	50,000	(b)		1,524	1,287,144	34,959	1,377,396
1897	200	800	2,084	16,672	100,000	0,000	(b)		1,728	1,564,333	32,378	1,328,443
1898	200	800	4,500	45,003	70,265	35,135	230	$575	1,691	1,593,921	31,361	1,252,024
1899	100	400	3,510	35,100	107,386	105,182	(b)		1,361	1,481,229	32,144	1,274,603

Year.	Salt.		Silver—Kg.		Silver Ore.		Soapstone.		Sodium Sulphate.	
1895	326,320	$952,098	58,546	$1,360,996	16,299	$75,836	2,347	$6,219	687	$3,636
1896	521,751	1,153,880	64,554	1,507,441	1,230	129,943	756	1,166	(b)	
1897	508,606	1,159,294	71,168	1,555,636	982	101,797	3,601	21,341	(b)	
1898	479,358	1,025,682	76,295	1,865,156	767	106,094	2,613	14,504	(b)	
1899	598,108	1,091,133	88,409	2,161,531	764	78,721	4,844	26,622	(b)	

Year.	Sulphur.		Sulphur, Crude Rock.		Tin Ore.		Topaz of Hinojosa. Kg.	
1895	2,231	$37,930	8,481	$22,049	17	$1,500	67	$1,385
1896	1,800	36,004	26,204	45,433	d2,348	5,908	80	12,860
1897	3,500	70,000	18,845	32,588	d2,378	5,795	44	751
1898	3,100	68,400	e105,757	198,138	4	468	90	1,454
1899	1,100	31,350	58,922	102,150	57	8,450	44	751

Year.	Tungsten Ore		Zinc.						
			Calamine, Calcined.	Ore.		Sheet.		Slabs.	
1895	14	$710	19,169	54,109	$370,007	2,487	$373,125	3,149	$302,266
1896	31	1,560	23,108	64,828	407,670	2,648	405,175	3,485	390,286
1897	10	309	(b)	73,848	363,846	2,337	378,594	3,907	445,212
1898	37	5,325	(b)	99,836	991,386	1,731	322,040	4,300	602,000
1899	151	14,142	(b)	119,710	1,208,987	2,084	387,624	4,100	574,000

(a) Figures for 1897 are from the *Reports of the Comisión Ejecutiva de Estadistica Minera*. The figures for 1895 1896 and 1898, are from the official *Reports of the Junta Superior Facultativa de Minas*, Madrid. There was also produced in 1896, lead and zinc ores, 400 metric tons, $400; in 1897, gold ore, 456 metric tons, $1,850; lead and zinc ores, 40 metric tons, $40; in 1898, lead and zinc ore, 38 tons, $38; gold, $2,338. (b) Not reported. (c) Represents non-argentiferous copper ore. (d) Undressed ore. (e) 70,814 tons, $152,309, of this product is the contents of copper pyrites from Huelva. (f) Gold ore only.

MINERAL IMPORTS OF SPAIN. (a) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Asphalt and Pitch.		Alkaline Carbonates		Coal.		Coke. (b)		Gold Bars—Kg.	
1895	33,766	$675,316	27,591	$1,219,755	1,515,506	$8,190,270	255,043	$1,377,232	c	
1896	35,401	566,427	27,014	1,188,641	1,447,345	8,262,168	234,033	1,115,516	337	$235,900
1897	23,324	368,700	28,428	1,210,426	1,633,333	8,837,595	214,763	1,159,731	268	187,600
1898	28,720	459,528	26,574	1,169,245	1,224,345	7,466,073	196,224	1,177,346	2	1,440
1899	37,827	605,231	34,805	1,395,614	1,555,800	9,134,802	208,789	1,252,735	10,210	7,555,400

Year.	Gold Coin	Iron, Pig.		Iron, Bar.		Iron and Steel, Forged.		Petroleum, Crude.		Silver Bars. Kg.	
1895	$119,945	12,385	$173,389	7,768	$354,289	18,233	$753,267	46,592	$1,211,397	4,286	$120,008
1896	16,231	8,577	120,087	13,861	607,539	26,463	1,398,827	34,427	1,233,345	5,576	150,812
1897	12,149	1,855	25,972	13,558	571,043	24,037	1,472,690	34,972	1,259,011	243,540	6,341,894
1898	(c)	1,575	28,352	(c)		5,164	267,159	32,731	1,505,671	153,475	4,143,825
1899	(c)	2,267	40,793	(c)		5,687	256,119	23,522	1,082,019	46,504	1,209,104

Year.	Silver Coin.	Sodium Nitrate.		Sulphur.		Tin Plate.		Tin Ingots.	
1895.....	$4.776,929	26,385	$1,583,129	6,813	$1,219,755	1,241	$104,223	825	$379,625
1896.....	20,190,400	26,841	1,610,495	7,744	185,870	1,071	89,977	1,080	432,001
1897.....	22,325,312	34,862	2,091,729	5,310	128,883	565	46,098	923	369,359
1898.....	(c)	38,322	2,146,035	5,665	158,621	653	52,237	833	350,028
1899	(c)	56,408	3,158,871	6,385	178,791	1,661	132,859	937	393,492

(a) The figures for 1895, 1898 and 1899 are from the *Anuario de la Mineria Metalurgia y Electricidad de España*, while those for the years 1896 and 1897 are from the *Revista Minera*, Madrid, Feb. 18, 1898. (b) In terms of coal. (c) Not reported.

MINERAL EXPORTS OF SPAIN (a) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Antimony Ore.		Cement, Hydraulic		Coal.		Copper Ore.		Copper, in Matte and Precipitate.	
1895.....	26	$1,566	2,807	$16,841	8,320	$44,927	530,075	$4,796,335	36,210	$4,213,024
1896.....	119	7,190	(b)		4,295	23,205	629,546	5,665,918	46,417	4,385,213
1897.....	20	1,176	(b)		2,539	13,300	822,570	5,613,482	51,487	7,373,928
1898.....	50	2,982	(b)		2,643	14.277	899,238	6,474,516	49,570	7,466,956
1899.....	92	5,537	(b)		8,073	45,518	948,917	6,852,205	44,008	6,638,755

Year.	Iron Ore.		Iron Pyrites.		Iron and Steel.		Lead Ore.			
							Argentiferous.		Non-Argentiferous.	
1895.....	5,175,260	$9,315,468	490,709	$981,419	79,157	$3,654.863	8,349	$534,352	1,979	$94,516
1896.....	6,289,257	11,320,670	464,882	920,977	23,085	233,270	c6,270	392,668	(b)	
1897.....	6,884,244	13,180,064	217,545	569,287	43,612	610,776	c8,267	462,595	(b)	
1898.....	6,558,060	14,427,736	256,341	615,218	46,127	830,291	7,191	410,178	(b)	
1899.....	8,606,558	18,934,429	319,285	766,881	40,879	735,826	19,353	594,078	(b)	

Year.	Lead, Pig.				Manganese Ore.		Quicksilver.		Salt.	
	Argentiferous.		Non-Argentiferous.							
1895.....	87,299	$5.587,115	67,187	$3,238,438	30,007	$282,269	1,330	$1,489,194	253,391	$760,174
1896.....	d166,124	9,500,935	(b)		87,835	827,620	1,559	1,746,154	254,752	764,257
1897.....	d171.774	10.122,220	(b)		95,756	1,091,621	1,742	1,436,293	235,871	707,616
1898.....	d178,517	11,340,015	(b)		139,050	1,597,706	1,741	1,880,703	219,670	659,099
1899.....	d161,098	9,987,370	(b)		139,352	1,588,815	3,221	3,478,789	331,081	993,212

Year.	Silver—Coin, Jewelry, etc.		Soapstone.		Sulphur.		Tin.		Zinc.		Zinc Ore.	
1895....	277	$8,397,770	1,415	$45,272	83	$2,152	10	$4,937	1,367	$136,690	29,360	$267,957
1896....	(b)		(b)		(b)		(b)		3,560	356,060	36,656	308,272
1897....	(b)		(b)		(b)		(b)		2,170	239,716	41,040	353,121
1898....	(b)		(b)		(b)		(b)		4,553	500,791	65,573	697,473
1899....	(b)		(b)		(b)		(b)		2,390	260,889	95,088	989,671

(a) From the *Anuario de la Mineria Metalurgia y Electricidad de España*, Madrid, except 1895, which is from the *Estadistica Minera de España*. (b) Not reported. (c) Includes non-argentiferous lead ore. (d) Includes non-argentiferous.

SWEDEN.

THE official statistics of mineral production, imports and exports are summarized as follows:

MINERAL PRODUCTION OF SWEDEN. (*a*) (IN METRIC TONS.)

Year.	Alum.		Clay (Fire).		Coal.		Cobalt Oxi. Kg.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.	
1895..	286	(*c*)	120,385	(*c*)	223,652	(*c*)	(*c*)		216	(*c*)	94	(*c*)	26,009	(*c*)	1,195	(*c*)
1896..	334	$9,849	120,426	(*c*)	225,848	$435,891	(*c*)		249	$56,724	191	$2,483	24,351	$83,135	1,506	$105,300
1897..	131	3,826	112,283	(*c*)	224,343	434,710	700	$2,457	289	68,645	232	3,235	25,207	92,712	1,315	99,860
1898..	153	4,543	131,391	(*c*)	236,277	465,936	3,001	10,125	235	59,689	124	1,783	23,335	99,749	1,165	78,840
1899..	164	4,917	129,875	(*c*)	239,344	485,239	1,345	4,536	179	60,028	105	1,483	22,334	110,462	1,287	108,000

Year.	Feldspar.		Gold—Kg.		Gold Ore.		Iron.				Iron Ore.		Iron Ore. (Bog.)	
							Pig.		Bloom.					
1895..	(*c*)		85·2	(*c*)	459	(*c*)	462,920	(*c*)	188,726	(*c*)	1,904,662	(*c*)	2 691	(*c*)
1896..	12,789	$39,417	114·5	$76,806	736	$5,913	494,418	$8,233,999	188,396	$4,772,077	2,039,019	$2,518,175	925	(*c*)
1897..	19,298	53,992	113·3	75,517	1,662	9,214	538,197	9,467,855	189,633	5,045,705	2,086,119	2,700,639	1,047	(*c*)
1898..	20,737	64,572	125·9	106,318	2,136	6,136	531,766	9,414,123	198,923	5,407,843	2,302,546	2,969,986	368	(*c*)
1899..	16,017	50,041	106·2	71,081	*Nil.*		497,727	9,823,735	195,331	5,866,026	2,434,606	3,627,517	594	(*c*)

Year.	Iron and Steel Bars, Rods, Sheets, etc.		Lead.		Lead Ore.		Manganese Ore.		Mineral Paints.		Pyrites.		Silver. Kg.	
1895.....	284,504	(*c*)	1,256	(*c*)	7	(*c*)	3,117	(*c*)	1,291	(*c*)	221	(*c*)	1,188	(*c*)
1896.....	308,132	$12,036,504	1,530	$76,033	14	$491	2,056	$7,251	(*c*)		1,009	$2,914	2,082	$44,263
1897.....	304,537	12,624,486	1,480	76,876	99	3,240	2,749	12,810	(*c*)		517	1,496	2,218	41,471
1898.....	299,846	11,943,458	1,559	102,464	50	1,620	2,358	11,142	(*c*)		386	1,037	2,033	38,887
1899.....	328,999	14,223,434	1,606	106,846	35	1,134	2,622	12,080	(*c*)		150	364	2,290	43,411

Year.	Silver and Lead Ore.		Steel.						Sulphur.		Zinc Ore		Zinc Ore. (Calcined.)	
			Bessemer.		Crucible.		Martin.							
1895....	12,045	(*c*)	97,320	(*c*)	598	(*c*)	99,259	(*c*)	(*c*)		31,349	(*c*)	(*c*)	
1896....	15,381	$75,252	114,120	$3,091,384	604	$53,318	142,301	$3,851,974	77	(*c*)	44,041	$330,738	23,000	$322,920
1897....	10,068	63,123	107,679	3,091,109	691	73,540	165,836	4,652,524	(*c*)		56,636	494,742	24,583	358,420
1898....	6,743	53,631	102,254	2,836,079	1,013	106,318	160,706	4,512,212	50	$1,620	61,627	603,647	25,250	443,187
1899....	5,730	60,070	91,898	2,710,926	1,225	126,765	179,357	5,549,696	(*c*)		65,159	743,869	24,200	516,186

(*a*) From *Bidrag till Sveriges Officiela Statistik. Bergshandteringen.* In 1899 there was also an output of 500 tons of graphite ore valued at $540. (*c*) Not reported.

MINERAL IMPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Aluminum Sulphate.		Ammonium.										Antimony Crude.	
					Carbonate.		Chloride.		Hydrate.		Nitrate.		Sulphate.			
1895	93	$2,760	348	$4,704	74	$16,045	84	$18,181	76	$6,147	11	$4,258	39	$3,133	81	$15,234
1896..	75	2,223	629	8,494	79	17,114	88	18,983	81	7,279	11	4,609	88	7,132	63	11,822
1897..	103	3,072	733	9,896	109	20,516	110	20,873	59	5,605	42	9,013	67	4,536	58	11,053
1898 .	136	4,036	968	13,074	99	18,723	101	19,168	105	9,886	12	2,565	81	5,477	53	9,936
1899..	158	4,688	866	11,699	89	16,900	112	21,164	110	10,391	12	2,561	181	12,221	59	11,170

Year.	Arsenious Acid.		Asbestos. (c)		Asphalt. (d)		Barytes.		Borax.		Boric Acid.		Bromine and Bromides of Potassium and Sodium. Kg.	
1895....	36	$3,910	68	$18,278	3,256	$35,161	240	$12,939	111	$14.999	54	$8,674	3,999	$3,239
1896....	33	3,587	116	31,407	4,092	44,190	298	16,084	128	17,243	73	11,807	4,334	3,511
1897....	33	3,523	119	32,151	5,458	58,947	270	14,595	175	18,952	56	9,006	5,549	4,495
1898....	33	4,390	112	30,359	5,409	58,420	299	16,140	196	21,148	75	12,071	5,401	5,687
1899....	12	1,642	567	153,195	6,286	67,893	292	15,812	190	20,529	65	10,596	4,914	5,175

Year.	Cement.		Chalk. White, Unground. *Hektoliters.*		Chalk. Other Kinds. (e)		Chemico-Technical Preparations N.E.S. (f)	Chloride of Lime		Clay Products. Brick & Tiles.	Clay.	Clay Products. Porcelain.	
1895....	4,270	$40,354	4,466	$482	109	$1,579	$69,962	1,250	$53,982	$117,188	$69.178	277	$211,033
1896....	2,901	27,411	6.148	664	146	1,143	87,835	1,600	69,116	196,482	79,655	327	247,878
1897....	1,826	17,259	14.368	1,552	142	1,069	100,021	1,676	72,388	263,379	80,010	362	273,784
1898....	1,656	15,652	7,016	758	308	1,313	115,499	1,668	72,048	359,374	109,738	298	213,572
1899....	1,363	12,877	16,079	1,737	86	1,402	121,878	2,402	103,777	267,299	95,582	346	244,637

Year.	Coal (g)		Copper, and Copper in Alloys and Metals.		Copper & Iron Sulphates.	Emery.		Glass and Glassware. (h)		Gold Bars, and Gold M'f'res. Kg.		Gold Coin.	Graphite.	
1895..	1,911,629	$8.387,275	2,930	$738,512	$4,554	125	$16,824	1,619	$452,276	89	$59,354	$11,600	134	$7,244
1896..	1,991,760	8.402.736	4.037	947,930	11,028	104	14,004	2,477	447,352	1.161	107,001	608	135	7.311
1897..	2,240,247	9,829.086	4.944	1,156,202	5,805	128	17.296	1.618	507,491	4.267	2,086,848	948	158	8,519
1898..	2,392,451	12.112,784	5.227	1.220.805	6,512	131	17.649	2.560	551.169	3,998	1,875.585	2,396	167	9,008
1899..	3,047,618	16,457,135	4.740	1,105,524	11,202	125	16,902	2,213	532,609	362	287,075	9,774	162	8,729

Year.	Gypsum. (j)		Iron and Steel. Crude.		Iron and Steel. Manufactures.	Lead, Crude.		Lime. *Hektoliters.* (k)		Litharge.		Nitric Acid.	
1895....	4,112	$30,347	40,582	$878,005	$2,549,183	1,624	$149,729	4,436	$1,628	117	$15,760	36	$2,933
1896....	4,940	37,274	34,549	878,383	3,703,338	1.911	180,749	7,768	2,619	150	20,202	32	2,574
1897....	7,260	75,270	89,606	1,420,175	3,785,043	2.098	206,076	20,050	7,389	199	26,925	41	3.285
1898....	7,979	66,187	76,882	1,326.910	4,641,613	2.139	207.342	23,079	8,724	160	21,592	34	3,252
1899....	6,457	65,486	68,909	1,282,713	5,867,895	2,125	215,996	34,343	10,732	177	23,918	77	7,303

Year.	Phosphorus. Kg.		Platinum. Kg.		Potassium. Chloride.		Potassium. Cyanide. Kg.		Potassium. Hydrate. (Caustic.)		Potassium. Oxide.		Quicksilver. Kg.	
1895....	71,407	$86,760	42	$7,938	561	$113,699	1,457	$1,180	91	$29,398	1,979	$187,019	6,318	$7,166
1896....	52,482	63,766	34	6,426	241	45,508	2,122	1,719	285	92,217	1,933	182,688	5.194	5,890
1897....	57,972	70,436	63	11,907	363	58,817	2,922	2,367	1,381	410,247	1,432	135.370	3,125	3.544
1898....	66,466	80,756	49	9,261	259	28,006	2,604	1,757	1,451	431,030	1,112	105.119	2,631	2.983
1899....	59,989	72,887	59	11,151	225	36,466	2,313	1,561	1,266	376,029	1,231	116.293	4,210	4,774

Year.	Salt. Common.		Salt. Refined.		Sand.	Silver and Man'factures Kg.		Silver Coin.	Sodium Salts. Carbonate.		Sodium Salts. Hydrate.	
1895....	106,820	$446,003	2,535	$102,685	$15,440	3,050	$65,880	$114,340	12,711	$240,240	1,043	$56.319
1896....	84.629	318,011	3,673	148,755	30,428	7,375	217,141	204,691	11,425	215,932	908	49,051
1897....	87,050	411,548	3,055	148,479	19,509	20.557	473,801	136,823	14.625	276,417	625	33.764
1898....	85,246	403,380	2,188	106,332	29,169	21.696	442,622	191,766	11,917	225,230	575	31,064
1899....	98,417	410,917	3,166	153,884	35,848	11,565	304,825	156,707	13,323	251,806	929	50,151

Year.	Sodium Salts.—*Continued.* Nitrate. (l)		Sodium Salts.—*Continued.* Sulphate. (i)		Stone. (m)	Sulphur.		Sulphuric Acid.	Tin. (Crude.)		Tin and Lead Ashes.		
1895.....	9,388	$446,851	7,420	$200,332	$35,363	7,140	$173,491	772	$15,638	462	$162,085	7	$7.235
1896.....	12,518	565,900	8,486	229,121	122.525	11,369	276.265	615	12,455	551	170,307	11	12,132
1897.....	12,531	602,709	11,384	153,683	227,476	9,723	236,269	1,418	28,709	541	196,478	16	28,709
1898.....	15,419	685,657	11,544	172,435	103.260	10,837	263,341	1.742	35,273	595	224,890	25	27,455
1899.....	15,006	708,150	15,140	204,384	98,648	13,505	328,165	2,558	51,797	486	295,458	8	8,704

Year.	Tin Salts.		Zinc.	
1895....	4,091	$1,105	2,216	$198,289
1896....	4,437	1,198	2,275	230,865
1897....	3,823	1,032	2,551	261,249
1898....	3,874	1,046	3,030	343,014
1899....	5,404	1,459	2,829	343,758

(*a*) From *Bidrag till Sveriges Officiela Statistik.* (*c*) Includes raw product and manufactured articles. (*d*) Natural and artificial asphalts. (*e*) Ground chalk, pastels, etc. (*f*) N. E. S.—*Not elsewhere specified.* (*g*) Includes coal-dust. (*h*) Exclusive of powdered glass. (*i*) Includes also sodium bisulphate. (*j*) Raw, ground and calcined gypsum. (*k*) Slaked and unslaked lime. (*l*) Includes both sodium and potassium salts. (*m*) Building stone, etc.

MINERAL EXPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Ammonium Sulphate.		Antimony, Crude.		Asbestos. Kg.		Cement.		Chalk.				Chemico-Technical Preparations.
											Unground. *Hektoliters.*		All Other.		
1895....	38	$1,140	(*b*)		2·3	$440	28	$7	31,029	$251,333	111	$12	3,453	$18,815	$39,667
1896....	40	1,184	100	$8,138	0·8	144	2,040	551	22,991	186,228	164	18	4,382	23,747	34,532
1897....	54	1,604	180	12,150	0·8	156	1,348	364	27,112	219,611	1,188	128	4,422	24,032	40,351
1898....	32	947	36	2,491	4·7	896	1,055	285	28,676	232,276	365	39	4,844	26,209	80,377
1899....	26	772	2	124	2·6	497	2,812	759	31,101	251,917	616	66	5,392	29,550	124,948

Year.	Clay.	Clay Manufactures.	Coal.		Copper and Iron Sulphates	Copper Ore.		Copper and Copper in Alloys and Metals.		Glass, All Kinds.		Graphite. Kg.	
1895....	$17,360	$467,380	52	$182	$90,501	(*b*)		2,283	$269,066	7,150	$1,221,319	9,749	$526
1896....	28,869	589,159	141	594	121,524	1,094	$73,856	1,911	218,849	10,674	1,378,125	3,500	189
1897....	28,931	684,340	74	325	97,449	(*b*)		933	425,089	9,399	1,134,495	7,215	390
1898....	43,005	641,730	496	2,513	92,191	1,102	7,441	1,346	293,159	9,838	1,143,037	9,108	492
1899....	46,589	642,079	762	4,112	129,676	315	3,337	1,230	269,423	9,194	756,683	16,664	900

Year.	Gypsum and Manufactures.		Iron Ore.		Iron and Steel.			Lead and Manufactures.		Lime. *Hektoliters.*	
					Unwrought.		Manufactures.				
1895....	20·0	$12,260	800,452	$1,512,855	311,866	$8,653,212	$1,794,270	1,380	$74,712	40.287	$13,456
1896....	9·3	7,436	1,150,695	1,905,550	304,138	9,320,969	1,975,068	1,182	67,750	102,787	29,453
1897....	9·6	5,727	1,400,801	2,779,890	279,525	9,175,910	2,373,230	1,473	91,993	106,053	31.925
1898....	27·3	2,609	1,439,860	2,942,930	301,192	9,399,827	1,644,096	570	36,090	123,939	40,401
1899....	8·3	1,384	1,628,011	3,406,613	320,742	11,393,918	2,109,433	818	62,049	80,153	25,391

Year.	Peat.		Phosphorus. Kg.		Potassium Chlorate.		Salt, Refined. Kg.		Sand.	Silver.			
										Bullion—Kg.		Manufactures—Kg.	
1895....	1,143	$3,087	885	$1,075	436·4	$88,377	1,661	$67	$511	751	$15,918	10	$540
1896....	1,452	3,920	1,510	6,795	253·7	47,958	830	34	2,232	819	17,359	14	756
1897....	1,816	4,902	1,627	1,977	462·5	74,927	1,424	69	969	329	6,396	119	6,426
1898....	1,616	4,364	4,085	4,963	506·4	82,041	216	11	3,336	130	2,492	238	12,744
1899	1,979	5,342	1,890	2,296	334·9	54,259	110	5	1,929	367	7,134	258	13,930

Year.	Soda.		Sodium Sulphate.		Stone. (*c*)	Sulphur.		Sulphuric Acid.		Tin and Lead Ash.		Tin.			
												Ingot.	Manufactures—Kg.		
1895....	959	$18,128	12·9	$348	$1,420,508	11	$271	3·1	$85	7·6	$8,245	13·3	$4,683	786	$459
1896....	772	14,599	6·8	184	(*b*)	9	214	6·6	178	7·6	8,197	18·9	6,367	2,996	1,636
1897....	686	12,970	3·4	46	2,062,011	11	258	7.6	205	1·7	1,836	25·6	8,305	7,113	4,328
1898....	509	9,618	5·1	69	2,385.736	11	272	2·8	76	15·8	17,013	20·8	7,591	1,263	724
1899....	227	4,298	13·2	180	2,613,158	68	730	2·7	74	20·6	22,211	8·8	5,371	1,033	592

Year.	Zinc.				Minerals, Not Specified.	
	Ore.		Crude and M'frs.			
1895.....	33,075	$312,562	26	$3,130	5,631	$87,791
1896.....	41,401	458,306	184	11,789	2,704	43,766
1897.....	44,425	527,769	135	9,009	442	5,423
1898.....	49,597	723,129	184	13,799	2,596	40,526
1899.....	45,634	788,564	157	13,324	197	1,597

(*a*) From *Bidrag till Sveriges Officiela Statistik.* (*b*) Not stated in the reports. (*c*) Building stone, etc., wrought and unwrought.

UNITED KINGDOM.

THE statistics of the mineral production, imports and exports, are given in the subjoined tables. The statistics of the most important substances for 1900 will be found under the respective captions elsewhere in this volume.

MINERAL PRODUCTION OF THE UNITED KINGDOM. (*a*) (METRIC TONS AND DOLLARS; £1=$5.)

Year.	Alum Shale.		Arsenic.		Arsenical Pyrites.		Barytes.		Bauxite.		Chalk.	
1895.....	2,096	$1,290	4,875	$260,990	2,998	$13,925	21,509	$115,295	10,574	$12,530	2,971,023	$769,320
1896.....	*Nil.*		3,674	227,415	8,949	40,035	24,117	127,950	7,365	9,590	3,616,177	785,850
1897.....	621	380	4,232	373,975	13,347	53,670	23,087	120,585	13,540	14,115	3,920 183	827,975
1898.....	13,835	8,510	4,241	268,935	11,272	40,720	22,581	116,265	12,600	14,490	4,366,782	903,255
1899.....	5,913	3,640	3,890	271,180	13,735	60,690	25,059	128,220	8,137	9,355	4,752,982	1,048,125
1900.....	(*h*)		4,146		9,727		27,895		5,871		(*h*)	

Year.	Clay. (*b*)		Coal.		Copper Ore.		Copper Precipitate.		Fluorspar.	
1895.....	9,952,823	$9,198,035	192,695,944	$286,156,065	7,651	$109,560	264	$14,275	37	$270
1896.....	11,523,250	7,210,345	198,487,040	285,950,735	9,113	107,930	201	10,620	400	2,390
1897.....	12,908,479	7,265,640	205,364,010	298,700,045	7,246	93,530	224	11,600	302	1,985
1898.....	14,974,290	8,081,790	205,287,388	320,846,910	9,145	129,245	132	6,500	57	245
1899.....	15,305,895	7,713,285	223,616,279	417,405,685	8,274	168,990	178	7,750	796	4,205
1900.....	(*h*)		228,772,886		9,233		(*c*)		1,436	

Year.	Gold Ore.		Graphite.		Gravel and Sand.		Gypsum.		Iron Ore.		Iron Ore. Bog. (*d*)	
1895.....	13,478	$82,920	41	$500	1,030,709	$405,535	180,738	$359.175	12,817,261	$14,328,545	5,742	$7,065
1896.....	2,809	21,285	*Nil.*		1,268,310	450,100	196,404	372,690	13,919,976	15,752,120	6,758	8,315
1897.....	4,589	31,410	*Nil.*		1,378,496	556,660	184,287	334,890	14,008,484	16,088,975	7,238	8,905
1898.....	715	5,790	*Nil.*		1,652,701	677,690	199,174	356,580	14,403,769	17,033,140	5,505	6,770
1899.....	3,096	50,850	*Nil.*		8,856,380	661,995	275,974	382,280	14,692,711	19,477,425	4,390	5,400
1900.....	21,135		(*h*)		(*h*)		(*h*)		(*h*)		(*h*)	

Year.	Jet—Kg.		Lead Ore.		Manganese Ore.		Mineral Paints.		Oil Shale.		Petroleum.		Phosphate, Lime.	
1895.....	76	$80	39,026	$1,366,960	1,293	$3,405	7,747	844,945	2,282,815	$2,808.580	15	$140	2,540	$21,875
1896.....	133	50	41,726	1,516,990	1,097	3,065	10,049	123,440	2,458,237	3,024,405	12	145	3,048	26,250
1897.....	31	40	35,903	1,377,045	609	1,755	14,653	64,985	2,259,325	2,779.680	12	145	2,032	17,500
1898.....	*Nil.*		33,513	1,337,010	235	1,000	20,144	65,015	2,172,201	2,672,490	6	70	1,575	13,565
1899.....	*Nil.*		31,494	1,483,920	422	1,245	16,575	67,895	2,246,197	2,765,015	5	60	1,469	12.645
1900.....	(*h*)		32,487		1,384		(*h*)		2,318,736		(*h*)		(*h*)	

Year.	Pyrites.		Salt.		Silica.				Slag.		Slates and Slabs.	
					Chert and Flint		Quartz.					
1895.....	9,193	$20,570	2,208,025	$3,548,755	96,304	$83,305	736	$2,750	137,040	$29,440	591.068	$6,370,730
1896.....	10,177	23,015	2,054,715	3,333,065	109,694	85,150	527	1,945	571,290	76,796	596.324	6,691.280
1897.....	10,752	22,625	1,933,949	3,104,490	95,209	82,475	459	1,695	(*e*)		618,941	8.247.880
1898.....	12,302	24,020	1,908,723	3.100,575	83,370	72,565	*Nil.*		(*e*)		679,461	9,501,140
1899.....	12 426	23,385	1,945,531	3,220,870	69,955	66,080	*Nil.*		(*e*)		650,077	8,935,355
1900.....	12,484		(*h*)		(*h*)		(*h*)		(*h*)		(*h*)	

Year.	Stone.								Strontium Sulphate.	
	Granite.		Limestone. (*f*)		Sandstone.		Whinstone, Basalt, etc.			
1895.....	1,694.450	$2,739,995	9,677,440	$6,026,305	4,299,714	$6,832,980	1,756,004	$1,761,910	12,469	$18,645
1896.....	1,784,925	2,490,370	11,187,532	6,078,020	4,579,869	7,089,925	2,323,591	2,127,935	18,331	25,940
1897.....	1,876.880	2,763,020	11,179,580	5,779,965	5,043,535	7,623,500	2.393,243	2,206,955	15,227	21,550
1898.....	1,905,830	2,882,286	12,172,267	6,280,770	5,325.988	8,163,930	2,644,131	2,327,715	13.148	18,370
1899.....	4,785,284	5,478,815	12,499,736	6,675,335	5,296,026	8,268,520	(*g*)		12,831	31,570
1900.....	(*h*)		(*h*)		(*h*)		(*h*)		(*h*)	

Year.	Tin Ore (Black Tin.)		Tungsten Ore.		Uranium Ore.		Zinc Ore.	
1895	10,782	$1.852.650	*Nil.*		41	$10,355	17,758	$247,150
1896	7,786	1,299,640	44	$6,775	36	7,500	19,588	332,225
1897	7,234	1,271,090	127	10,040	30	6,835	18,586	345.770
1898	7,498	1,441,625	331	79,220	26	5,925	23,929	588,920
1899	6,494	2,202,545	96	19,155	7	1,375	23,505	697.410
1900	6,096		8		42		25,070	

METALS OBTAINABLE BY SMELTING FROM THE ORES IN THE ABOVE TABLE. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Copper, Fine.		Gold—Kg.		Iron.		Lead.		Silver—Kg.		Tin.		Zinc.	
1895	589	$136,315	205·3	$92,600	4,465,307	$52,671,625	29,465	$1,543,670	8,722	$174,540	6,754	$2,233,900	6,760	$508,475
1896	565	140,900	42·1	25,175	4,835,597	56,877,370	31,311	1,754,700	8,828	181,825	4,915	1,538,390	7,224	616,200
1897	526	135,480	63·2	35,925	4,942,679	56,973,895	26,988	1,662,890	7,750	143,070	4,524	1,456,630	7,162	634,115
1898	650	177,615	12·3	6,495	4,928,347	63,700,215	25,761	1,664,975	6,575	118,640	4,722	1,729,060	8,711	897,910
1899	647	249,840	103·5	60,430	4,992,468	85,174,370	23,929	1,776,895	5,969	109,710	4,077	2,540,470	8,837	1,100,660

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Including china clay, potters' clay, and fuller's earth; and for 1895 and 1896 comprises a large quantity of ordinary brick clay not included in the returns of previous years. (*c*) Included with copper ore. (*d*) Bog ore, which is raised in Ireland, is an ore of iron, used principally for purifying gas. (*e*) Not reported. (*f*) Not including chalk. (*g*) Included with granite. (*h*) Statistics not available at time of publication.

Additional products: In 1897: Mica, 5,063 metric tons, $8,635; soapstone, 28 metric tons, $490; nickel ore, 305 metric tons, $1,500. Metals obtainable by smelting in 1897: Aluminum, 315 metric tons, $229,400; nickel, 7½ metric tons, $5,250; sodium, 86 metric tons, $63,750.

MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*) (METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Alkali.		Asphaltum.		Borax.		Brass and Bronze Manufactures.	Chemical Products.	Clay Products, Porcelain and Earthenware.		Coal, Culm and Cinders.		Copper. Man'f'res Unenumerated.	
1895	9,353	$572,930	27,399	$364,880	(*b*)		1,637	$854,905	$6,383,350	12,082	$3,432,875	16,525	$215,440	$910,500
1896	8,949	480,650	29,069	394,790	(*b*)		2,075	1,096,020	6,922,975	16,444	4,223,745	16,000	130,075	1,243,000
1897	11,557	545,010	44,541	519,080	(*b*)		2,129	1,045,985	6,781,900	17,847	4,523,940	9,605	87,555	1,882,425
1898	12,179	673,180	46,398	635,110	1,255	$77,140	2,357	1,068,330	6,939,150	16,405	4,301,740	11,191	81,550	2,662,400
1899	12,078	669,390	52,064	807,840	3,076	154,075	1,988	919,930	7,478,170	18,341	4,604,100	1,777	16,985	3,408,800
1900	16,360	840,790	(*c*)		15,667	777,045	(*c*)		7,493,120	(*c*)		(*c*)		(*c*)

Year.	Copper.—*Continued.* Ore.		Regulus and Precipitate.		Wrought, Unwrought & Old.		Diamonds—*Carats.*		Glass, All Kinds.	Gold Leaf. *Number.*	
1895	101,353	$2,873,015	92,727	$11,164,775	46,493	$9,588,485	3,607,750	$23,770,425	$12,375,880	66,138,410	$641,105
1896	88,732	2,833,955	92,252	11,477,545	66,405	15,013,905	3,527,810	22,995,830	12,537,885	70,483,026	694,265
1897	83,916	2,383,130	90,008	11,378,900	62,055	15,200,790	3,472,916	22,176,300	15,034,555	68,173,400	666,595
1898	91,141	3,291,150	76,201	9,779,790	70,018	17,988,325	3,476,509	22,619,075	16,423,915	63,632,700	624,960
1899	130,611	5,460,735	84,015	12,562,945	60,502	21,572,275	2,730,502	20,597,910	16,044,400	49,108,570	486,430
1900	103,076	5,865,210	89,123	17,587,530	72,223	26,384,295	(*c*)		15,982,460	(*c*)	

Year.	Gold Ore.		Graphite.		Iron. Bar, Angle, Bolt and Rod.		Iron and Steel Mfres	Iron and Steel, Old and Scrap.		Ore.	
1895	865	$1,001,345	10,526	$887,100	68,833	$2,747,670	$15,494,510	15,966	$246.220	4,521,516	$14,889,760
1896	2,263	604,015	13,861	1,121,195	72,195	2,852.060	22,055,335	15,578	295,555	5,525,320	18,893,945
1897	1,074	736,415	13,472	1,104,430	69,222	2,697.545	27,894,295	20,735	344.610	6,064,179	22,179,670
1898	1,019	1,393,175	15,113	1,506,805	70,331	2,782,745	33,379,160	24,619	349,230	5,555,889	20,173,210
1899	295	761,755	17,777	2,307,935	74,326	2,880.790	39,527,075	32,427	452,130	7,168,061	26,875,190
1900	(*c*)		(*c*)		81.436	3,281,165	41,536,105	(*c*)		6,398,639	28,195,015

Year.	Iron.—*Continued.* Pig and Puddled.		Steel, Unwrought.		Lead. Ore.		Pig and Sheet.		Manufactures.		Manganese Ore.	
1895	94,609	$2,156,360	11,036	$475,015	32,234	$797,400	165,531	$8,270,365	416	$60.180	133,623	$1,484,740
1896	108,152	2,206,220	17,771	788,730	57,172	1,448,245	170,484	9,298,715	218	51,895	162,542	1,844,740
1897	160,531	2,588,430	40,628	1,330,655	32,818	1,001,140	170,121	10,166,500	298	61,150	158,825	1,735,775
1898	162,075	2,688.445	40,875	1,263,025	44,457	1,512,535	197,591	12,606,780	419	66,830	156.390	1,700,555
1899	174,159	3,104,255	78.257	2,170,100	30,263	1,269,560	201,551	14.419.185	241	42,415	261,740	2,927,105
1900	184.049	4,025,495	182,210	6,090.895	(*c*)		198,416	16.597,870	(*c*)		(*c*)	

Year.	Mica, Sheet.		Mica and Talc.		Paraffine.		Petroleum. *Liters.*		Phosphate Rock.		Painters, Colors and Pigments.
1895....	373	$439,860	918	$241,355	36,612	$3,778,950	804,777,131	$16,844,520	365,414	$3,166,570	$4 369,55
1896....	431	528,050	1,753	520,425	36,850	3,555,250	862,960,772	18,660,280	295,975	2,329,655	4,950,635
1897....	412	554,480	1,683	570,595	39,284	3,375,055	842,920,307	16,676,355	330,335	2,466,060	5,049,225
1898....	517	711,855	1,398	419,095	48,104	4,045,160	829,995,751	18,668,150	334,834	2,499,360	5,619,835
1899....	519	710,630	6,025	701,880	54,712	5,055,335	908,107,248	22,863,945	426,830	3,414,700	5,842,063
1900....	(c)		(c)		(c)		1,162,454,512	27,872,665	(c)		(c)

Year.	Platinum, Wrought and Unwrought. Kg.		Potassium Nitrate.		Pyrites, Iron and Copper.		Quicksilver.		Silver Ore.	Slate.	Sodium Nitrate.	
1895....	1,883	$395,955	11,607	$1,068,265	591,782	$4,935,825	1,689	$1,672,790	$8,732,220	$358,445	124,650	$4,994,485
1896....	1,748	368,725	17,310	1,392,420	508,480	4,998,965	1,604	1,638,645	6,483,680	940,890	108,148	4,182,760
1897....	2,257	437,385	16,744	1,233,495	633.009	5,104,480	1,862	1,954,405	7,149.210	1,538,660	107,525	059,325
1898....	3,389	734,205	13,323	1,016,215	665,544	5,404.415	1,856	1,940,880	5,729,525	1,646,005	132,412	864,005
1899....	5,404	1,177,870	12,635	1,022,425	712,393	5,821,335	1,759	2,077,150	5,162,750	1,690,720	163,387	5,348,875
1900....	(c)		12,793	1,074,875	752,605	6,184,205	1,113	1,486,215	(c)	(c)	(c)	

Year.	Stone, Marble, Hewn or Manufactured.		Sulphur.		Tin in Blocks, Ingots, Bars, or Slabs.		Tin Ore.		Zinc, Crude, in Cakes.	
1895....	584,082	$3,404,885	25,318	$496,835	42,267	$13,155,190	4,780	$746,105	63,525	$4,669,470
1896....	683,977	4,141,135	22,990	470,060	38,989	11,448,440	4,950	725,915	77,861	6,225,065
1897....	752,345	4,592,345	22,811	511,045	27,214	8,118,990	5,345	682,935	70,929	5,946,945
1898....	883,699	5,179,950	19,642	450,155	20,665	6,948,005	5,710	785,285	78,761	7,211,345
1899....	905,432	5,526,265	21,906	508,075	27,608	16,290,910	6,324	1,258,260	71,068	8,316,905
1900....	(c)		22,993	545,240	33,648	21,795,665	(c)		61,504	7,210,160

Year.	Zinc Manufactures.		Zinc Ore.		Ores, Unclassified.		Metals, Unclassified, Wrought, Unwrought, and Old.	
1895.....	19,670	$1,875,960	38,096	$739,450	46,104	$1,570,045	8,417	$2,377,890
1896.....	21,339	2,097,185	21,421	493,170	45,782	1,289,665	10,695	2,887,750
1897.....	21,395	2,194,365	25,238	583,345	72,675	1,959,095	16,000	3,678,235
1898.....	21,613	2,390,440	53,945	1,100,705	51,660	1,476,625	14,459	3,545,690
1899.....	21,521	2,969,650	38,143	1,121,870	80,322	1,899,360	13,475	4,095,120
1900.....	22,096	2,798,525	(c)		(c)		(c)	

(*a*) *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Statistics not available at time of publication.

MINERAL EXPORTS OF THE UNITED KINGDOM. (*a*) (IN METRIC TONS AND DOLLARS. £1 =$5.)

EXPORTS OF DOMESTIC PRODUCE.

Year.	Alkali.		Ammonium Sulphate.		Brass and Manufactures		Cement.		Chemical Products.	Clay Products For celain and Earth'nw.	Coal and Culm.	
1896	245,938	$6,210,865	130,130	$5,307,615	6,070	$2,463,115	359,429	$2,902,085	$11,532,200	$10,847,690	33,474,843	$71,898,560
1897	252,786	6,393,450	155,449	6,298,700	5,713	2,458,370	398,023	3,239,595	11,969,165	8,629,425	35,919,965	77,922,710
1898	191,578	5,033,025	139,806	6,450,155	5,418	2,346,205	331,648	3,053,615	12,577,815	8,253,640	35,619,365	85,779,115
1899	193,492	5,158,115	142,577	7,781,860	5,797	2,815,835	359,273	3,466,755	13,750,635	9,314,255	41,839,217	128,451,970
1900	185,783	5,604,310	(*m*)		6,131	3,157,625	365,742	3,365,310	17,125,190	10,193,970	46,845,739	193,032,230

Year.	Coke and Cinders.		Coal, etc., for Steam'rs (*b*)	Coal Products (*c*)	Copper Sulphate.		Copper.			
							Unwrought, In Ingots, etc.		Mixed or Yellow Metal.	
1896....	687,640	$2,191,980	$10,096,302	$9,168,630	53,464	$4,303,315	23,698	$5,697,555	11,428	$2,576,510
1897....	993,980	3,372,525	10,623,050	8,340,420	60,326	5,113,800	21,252	5,381,155	11,192	2,640,740
1898....	782,053	2,755,580	11,444,431	7.624,740	52.573	4,224,085	27,102	7,154,225	10,452	2,542,915
1899....	881,172	3,743,745	12,422,429	7.712,965	40,822	4,261,185	32,449	11,994,300	7,038	2,186,940
1900....	(*d*)	(*d*)	11,940,353	9,060,870	43,601	5,067,970	18,300	6,993,065	8,940	2,946,515

Year.	Copper.—*Con.*		Glass, All Kinds	Iron.							
	Wrought or Manufactured. N. E. S. (*e*)			Pig and Puddled.		Bar (Except Railroad), Angle, Bolt and Rod.		Railroad, of All Sorts.		Iron and Steel Wire and Manufactures. (Except Telegraph Wire.)	
1896....	15,593	$4,220,155	$4,462,445	1,077,128	$12,669,415	180,973	$5,471,445	759,625	$17,802,050	57,008	$4,519,975
1897....	15,275	4,445,120	4,359,535	1,219,958	14,461,865	170,285	5,421,865	795,983	19,293,670	52,471	4,332,965
1898....	13,765	4,629,430	4,410,205	1,058,973	13,684.020	152,911	4,978,125	619,976	15,081,290	44,954	3.864.220
1899....	11,231	4,296,590	4.578,415	1,401,365	23,921.785	161,679	6,136,680	601,266	15,652,560	50,041	4,441,005
1900....	19,164	7,201,390	5,172,910	1,451,406	29,993,655	159,628	7.705,290	471,383	16,011,255	39,104	4,522,835

Iron.—*Continued.*

Year.	Hoops, Sheets (Ungalvanized) and Boiler and Armor Plates.		Galvanized Sheets.		Black Plates for Tinning. (Iron and Steel.)		Tinned Plates.		Cast and Wrought, and Manufactures. N. E. S. (*e*)	
1896....	122,660	$4,226,140	248,348	$14,218,110	49,179	$2,389,995	271,234	$15,180,075	372,090	$23,598,635
1897....	120,868	4,483,370	231,319	12,810,420	59,663	2,844,645	276,260	15,186,395	382,179	24,426,375
1898...	102,638	3,916,335	230,219	12,653,350	59,289	2,706,435	255,797	13,768,540	361,927	23,630,065
1899....	111,773	4,661,900	242,167	15,607,050	86,936	4,139,790	260,735	15,838,415	363,855	26,160,490
1900....	86,382	4,696,840	251,203	18,942,885	66,810	3,524,335	278,338	19,891,880	344,901	29,362,285

Iron.—*Concluded.*

Year.	Old.		Steel, Unwrought.		Manufactures of Steel and Iron.		Total of Iron and Steel.	
1896.....	129,463	$1,694,535	302,198	$12,587,775	37,299	$4,650,350	3,607,204	$119,008,500
1897.....	99,259	1,195,925	304,249	13,033,895	47,626	5,706,825	3,750,122	123,198,215
1898.....	86,602	1,201,050	290,182	13,203,560	35,857	4,513,470	3 299,326	113,200,460
1899.....	118,262	1,952,620	333,837	16,842,310	45,181	5,109,295	3,777,098	140,463,900
1900.....	96,567	1,876,400	313,330	18,425,090	42,939	5,135,170	3,602,083	160,085,785

Year.	Lead.				Potassium Nitrate.		Mica and Talc.		Salt, Rock and Brine.		Slate.
	Pig.		Sheet, Pipe and Other Manufactures.								
1896..	18,976	$1,067,590	22,898	$1,549,245	29,994	$165,590	30	$33,125	671,510	$2,351,650	$954,920
1897..	20,749	1,254,985	20,162	1,437,585	23,372	117,995	39	55,100	680,477	2,332,620	1,043,110
1898..	18,964	1,231,360	19,720	1,499,410	26,859	134,610	89	69,065	698,882	2,300,075	938,905
1899..	24,083	1,512,850	19,840	1,667,135	25,668	131,725	70	62,400	638,213	2,237,030	934,605
1900..	(*f*)		(*f*)		25,659	128,295	(*f*)		556,704	2,289,150	(*f*)

Year.	Stone, All Kinds.		Tin, Unwrought.		Zinc.						Metals, Unclassified Wrought & Unwrought.
					Ore.		Crude.		Manufactures.		
1896....	40,144	$779,280	6,299	$1,987,390	168	$42,575	8,605	$545,195	1,034	$126,456	$2,683,240
1897....	24,381	578,895	5,050	1,616,000	303	78,660	6,951	484,055	1,047	134,440	2,963,185
1898....	27,569	606,930	5,557	1,974,430	324	93,365	7,577	618,875	1,227	168,685	3,164,995
1899....	30,728	612,690	4,785	2,937,655	408	144,420	5,492	561,460	1,249	207,280	3,559,880
1900....	(*f*)		5,713	3,816,700	(*f*)		(*f*)		(*f*)		(*f*)

EXPORTS OF FOREIGN AND COLONIAL PRODUCE. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Chemical Products.	Copper, Unwrought, Partly Wrought, and Old.		Glass.					Iron, Bar, Angle, Bolt, and Rod.		Steel, Unwrought.	
				Bottles, *Gross.*		All Other Kinds		Total.				
1896....	$1,093,585	9,809	$2,338,295	12,335	$24,895	3,324	$292,575	$317,470	16,882	$638,705	4,000	$167,345
1897 ...	1,295,400	10,207	2,526,150	11,666	26,670	4,320	376,305	402,975	21,842	962,905	4,244	194,980
1898....	1,509,195	13,454	3,578,710	12,694	29,875	3,961	353,905	383,780	26,891	1,135,450	2,619	154,480
1899....	1,085,185	24,515	9,160,530	13,768	29,915	3,172	257,180	287,095	19,058	879,680	3,289	149,165
1900....	1,178,710	19,163	7,201,390	18,638	52,685	2,150	159,150	211,835	11,116	547,065	2,837	139,870

Year.	Iron and Steel, N. E. S., Wrought and Manufactured. (*e*)		Petroleum. *Liters.*		Potassium Nitrate.		Quicksilver.		Tin, in Blocks, Ingots, Bars, or Slabs.	
1896.....	37,292	$3,712,450	11,709,283	$354,420	1,913	$152,765	1,198	$1,150,020	19,007	$5,669,945
1897.....	29,305	4,324,980	6,753,750	270,735	2,949	218,610	1,047	1,050,330	14,994	4,545,810
1898.....	29,509	5,658,860	6,479,451	217,200	2,775	203,030	1,157	1,199,500	15,885	5,310,350
1899.....	28,874	5,094,390	6,699,181	279,505	1,573	122,240	1,097	1,316,130	17,120	9,953,060
1900.....		4,348,005	9,077,474	354,495	1,581	128,295	880	1,188,705	20,069	13,101,260

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Number of tons shipped for the use of steamers engaged in the foreign trade. This not being an export in the ordinary acceptation of the term, the value thereof is not given in the trade returns. (*c*) Including naphtha, paraffine, paraffine oil and petroleum. (*d*) Included in exports of coal and culm for this year. (*e*) N. E. S. signifies "not elsewhere specified." (*f*) Statistics not available at time of publication.

UNITED STATES.

STATISTICS and full particulars of the mineral production of the United States will be found in the introduction and the articles on the different substances. We give below the mineral imports and exports for five years:

MINERAL IMPORTS OF THE UNITED STATES. (*a*)

Year.	Aluminum.							Ammonium Sulphate.			
	Crude.				Leaf.		Mfd.				
	Lb.	Kg.	Value.	Value per Kg.	Pkgs.	Value.	Value.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	698	316	$591	$1·87	4,657	$523	$2,305	21,254,639	9,641	$384,693	$39·90
1897.....	1,822	854	1,082	1·26	4,260	370	3,279	19,351,119	8,778	317,121	36·13
1898.....	60	27	30	1·11	2,000	174	4,675	11,057,762	5,016	210,073	41·88
1899.....	53,622	24,323	9,425	0·39	693	112	5,303	17,121,988	7,766	406,573	52·35
1900.....	256,559	116,374	44,455	0·38	1,103	102	3,111	24,024,188	10,897	591,937	54·32

Year.	Antimony.				Antimony Ore.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1896.....	2,402,562	1,090	$148,700	$136·42	1,180,828	535	$21,392	$39·98
1897.....	1,146,696	520	46,955	90·30	5,502,132	2,496	167,373	67·06
1898.....	2,025,133	919	143,909	156·59	3,725,222	1,690	50,256	29·74
1899.....	3,160,697	1,434	240,988	168·09	3,982,133	1,806	47,841	26·49
1900.....	3,632,843	1,648	285,749	173·41	6,035,734	2,738	78,581	28·70

Year.	Asbestos.			Asphaltum.			
	Crude. Value.	Manufactured. Value.	Total. Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	$229,884	$15,654	$244,738	95,233	96,757	$286,099	$2·95
1897.....	264,220	10,570	274,790	127,325	129,362	427,390	3·30
1898.....	287,636	12,899	300,535	67,711	68,794	202,452	2·94
1899.....	303,119	8,949	312,068	100,168	101,771	319,089	3·14
1900.....	331,796	24,155	355,951	111,557	113,342	404,921	3·57

Year.	Barium Sulphate.								Bauxite.			
	Manufactured.				Unmanufactured.							
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896....	2,467	2,506	$23,345	$9·32	509	517	$1,274	$2·46	4,765,974	2,161	$10,477	$4·84
1897....	1,300	1,321	13,822	10·46	502	510	579	1·14	5,924,639	2,695	10,515	3·90
1898....	687	698	8,678	12·43	1,022	1,038	2,678	2·58	2,690,240	1,220	4,298	3·47
1899....	2,111	2,145	22,919	10·69	1,739	1,767	5,488	3·11	14,931,840	6,773	23,768	3·51
1900....	2,454	2,493	24,160	9·69	2,568	2,609	8,301	3·18	19,389,440	8,795	32,967	3·75

Year.	Brass and Manufactures of. Value.	Chloride of Lime, or Bleach.				Cement.			
		Lb.	Metric Tons.	Value.	Value per Met. Ton.	Barrels. (b)	Metric Tons.	Value.	Value per Met. Ton.
1896.....	$157,798	99,491,335	45,129	$1,441,600	$31·94	2,668,624	484,192	$3,394,426	$7·01
1897.....	85,341	109,176,451	49,522	1,460,799	29·50	2,090,824	379,357	2,688,122	7·09
1898.....	24,611	108,462,828	49,198	1,229,978	25·00	2,013,819	365,385	2,624,228	7·18
1899.....	58,916	123,583,061	56,056	1,203,364	21·47	2,108,213	382,512	2,858,286	7·47
1900.....	20,113	132,518,478	60,110	1,524,205	25·36	2,386,687	433,037	3,330,445	7·69

Year.	Chrome Ore.				Chromic Acid.				Clays or Earths, Including Kaolin.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Kg.	Value.	Value per Kg.	Long Tons.	Metric Tons	Value.	Value per Met. Ton.
1896..	8,669	8,808	$187,400	$21·27	2,429	1,002	$387	$0 39	98,243	99,815	$707,826	$7·09
1897..	11,566	11,751	186,313	15·85	71,220	32,305	5,477	0·17	102,391	104,029	696,935	6·70
1898..	16,304	16,565	272,234	16·43	5,329	2,417	1,758	0·73	113,280	115,092	779,491	6·77
1899..	15,793	16,046	284,825	17·75	33,134	15,029	6,360	0·42	122,035	123,988	807,792	6·52
1900..	17,542	17,823	305,001	17·11	35,452	16,081	7,232	0·45	146,524	148,868	965,902	6·49

Year.	Coal.										
	Anthracite.				Bituminous.				Total.		
	Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Metric Tons.	Value.	Value Per Met. Ton.
1896	101,689	103,316	$237,717	$2·30	1,246,991	1,266,943	$3,488,115	$2·75	1,370,259	$3,725,832	$2·72
1897	3,281	3,333	8,720	2·62	1,276,963	1,297,394	3,423,434	2·64	1,300,728	3,432,154	2·64
1898	3,149	3,199	8,609	2·69	1,270,557	1,290,886	3,569,572	2·77	1,294,085	3,578,181	2·77
1899	61	62	245	3·95	1,400,461	1,422,868	3,882,430	2·73	1,422,930	3,882,675	2·73
1900	118	120	549	4·58	1,909,258	1,939,806	5,019,553	2·59	1,939,926	5,020,102	2·59

Year.	Coke.				Cobalt Oxide.				Copper, Ore and Regulus.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Kg.	Value.	Value per Kg.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	43,372	44,066	$114,713	$2·60	27,189	12,333	$36,212	$2·93	6,117,440	2,775	$348,629	$125·63
1897	35,193	35,756	98,558	2·76	24,771	11,236	34,773	3·09	11,587,520	5,256	816,590	155·36
1898	41,185	41,844	142,334	3·40	33,731	15,300	49,245	3·22	6,861,120	3,112	654,355	210·26
1899	27,855	28,301	142,504	5·04	46,791	21,224	68,847	3·24	70,866,880	32,145	2,243,583	65·56
1900	103,175	104,826	371,341	3·54	54,073	24,527	88,651	3·61	121,696,960	55,201	5,009,828	90·76

Year.	Copper, Ingots, Old, etc.				Copper, Manufactures. Value.	Copper. Total Value.	Cryolite.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896....	11,397,273	5,170	$961,920	$186·05	$85,123	$1,395,672	3,009	3,057	$40,056	$13·10
1897....	16,578,420	7,520	1,454,016	193·35	58,897	2,329,503	10,115	10,277	135,114	13·24
1898....	54,166,467	24,570	4,120,680	167·71	39,467	4,814,502	6,201	6,300	88,501	14·05
1899....	71,922,340	32,624	10,139,390	310·80	42,000	12,424,973	5,879	5,973	78,676	13·17
1900....	68,797,591	31,206	10,743,152	344·26	23,390	15,776,370	5,437	5,524	72,763	13·17

Year.	Earthen, Stone, and China Ware Value.	Emery Grains.				Emery Rock.				Emery Manufactures. Value.	Emery. Total Value.
		Lb.	Metric Tons.	Value.	Value per Met. Ton	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.		
1896....	$9,690,142	751,464	341	$26,520	$77·77	6,289	6,390	$119,667	$18·72	$1,971	$148,158
1897....	8,409,678	520,095	238	20,022	84·84	5,209	5,292	107,649	20·36	2,211	129,882
1898....	7,273,471	577,655	262	23,320	89·01	5,547	5,636	106,269	18·86	3,810	133,399
1899....	8,101,093	728,299	330	29,124	88·17	7,435	7,554	116,493	15·42	11,514	157,131
1900....	9,144,515	661,482	300	26,520	88·39	11,392	11,574	202,980	17·54	10,006	239,506

Year.	Fertilizers.									Gold and Silver in Coin and Bullion.	
	Guano.				Phosphates, Crude.				All Other. Value.		
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.		Gold.	Silver.
1896....	6,838	6,947	$88,231	$12·70	14,908	15,147	$116,415	$7·69	$897,227	$102,761,282	$12,504,577
1897....	4,931	5,019	55,709	11·12	8,019	8,147	65,137	8·00	1,295,804	29,081,760	12,146,750
1898....	5,259	5,343	56,933	10·66	66,129	67,187	303,635	4·52	1,045,113	153,146,159	9,572,310
1899....	2,700	2,743	26,787	9·76	115,913	117,768	523,258	4·44	986,127	40,070,599	8,940,842
1900....	5,967	6,062	63,758	10·52	138,039	140,248	794,944	5·67	1,400,336	45,703,256	14,699,531

Year.	Gold and Silver in Ores.		Iron Ore.				Pig Iron.			
	Gold.	Silver.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	$1,969,977	$17,775,163	682,806	692,999	$1,036,917	$1·49	56,272	57,172	$1,207,890	$22·87
1897.....	4,941,052	20,935,552	489,970	497,809	678,912	1·39	19,212	19,519	484,655	24·83
1898.....	5,017,793	19,559,070	187,093	190,086	253,243	1·33	25,152	25,554	704,431	27·56
1899.....	11,264,365	21,903,087	674,082	684,867	1,082,847	1·58	40,393	41,039	1,339,405	32·64
1900.....	21,041,988	25,080,574	897,792	912,157	1,303,196	1·43	52,565	53,406	1,907,361	35·71

Year.	Scrap Iron and Steel.				Bar Iron, Rolled and Hammered.				Bars, Railway, of Iron or Steel.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896	$8,250	8,382	$130,012	$15·51	36,458,326	16,538	686,733	$41·52	7,796	7,921	$207,648	$26·21
1897	1,549	1,573	12,433	7·26	31,349,707	14,220	614,318	43·20	415	422	15,939	37·77
1898	1,783	1,812	33,330	18·39	42,827,276	19,426	844,366	43·47	200	203	5,181	25·52
1899	10,925	11,100	168,045	15·14	44,333,056	20,109	942,347	46·86	2,134	2,168	70,751	32·65
1900	34,431	34,982	663,331	18·96	42,093,825	19,094	1,058,761	55·45	1,448	1,471	56,129	38·15

Year.	Hoop, Band, or Scroll.				Ingots, Blooms, Slabs, Billets, etc.				Sheet, Plate, and Taggers Iron or Steel			
	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	59,105	27	$5,664	$209·78	45,598,270	20,683	$1,657,805	$80·15	15,201,124	6,896	$328,421	$47·62
1897	61,916	28	2,873	102·61	38,600,934	17,509	1,523,410	87·00	5,854,990	2,656	170,385	64·15
1898	7,527	3	224	74·66	23,868,683	10,827	1,008,360	93·13	5,085,287	2,307	181,021	78·47
1899	1,485,720	674	33,392	49·54	28,225,647	12,803	1,287,725	100·58	15,777,163	7,156	464,297	64·88
1900	369,165	167	12,409	74·08	28,476,816	12,917	1,332,896	103·19	11,521,220	5,226	426,541	81·62

Year.	Ties for Baling Cotton.				Tin Plates, Terne Plates, and Taggers Tin.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1896.....	16,031,468	7,272	$235,830	$32·43	266,943,267	120,803	$6,140,161	$50·82
1897.....	235,154	107	3,686	34·45	187,825,880	85,198	4,366,828	51·25
1898.....	*Nil.*				149,576,525	67,847	3,311,658	48·81
1899.....	*Nil.*				131,970,441	59,861	3,738,567	62·45
1900.....	*Nil.*				135,264,881	61,356	4,617,813	75·26

Year.	Wire Rods.				Wire, and Articles made from.				Manufactures. Value.
	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	
1896.....	42,509,008	19,281	$811,224	$42·07	8,230,248	3,733	$492,961	$132·05	$7,602,238
1897.....	36,768,538	16,679	772,950	46·34	5,720,322	2,596	344,855	132·84	5,523,678
1898.....	35,807,368	16,242	767,909	47·28	4,516,761	2,049	318,553	155·46	5,299,542
1899.....	40,239,103	18,252	873,396	47·85	5,293,069	2,401	400,952	166·99	6,481,702
1900.....	47,245,140	21,430	1,212,594	56·58	4,138,991	1,877	409,087	217·90	8,746,986

Year.	Total Value of Iron Imports. (e)	Lead, Pig, Bars, Scrap, and in Ore.				Lead, Sheet, Pipe, Shot, etc.	
		Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.
1896.....	$19,506,587	160,318,517	72,720	$1,780,265	$24·48	216,820	98
1897.....	13,835,950	185,318,412	84,060	2,480,471	29·51	95,891	43
1898.....	12,474,572	179,291,290	81,326	2,535,362	31·18	242,759	110
1899.....	15,800,579	192,877,074	87,488	2,816,783	32·20	110,372	59
1900.....	20,443,908	224,343,349	101,761	3,824,192	37·58	27,945	13

Year.	Lead, Sheet, Pipe, Shot, etc.—*Continued.*		Lead, Other Manufactures. Value.	Lead, Total Value.	Manganese Ore.			
	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	$8,513	$86·87	*Nil.*	$1,788,778	31,489	31,993	$250,468	$7·82
1897.....	4,042	94·00	$814	2,485,327	39,574	40,207	340,945	8·48
1898.....	9,389	85·35	*Nil.*	2,544,751	114,885	116,723	831,967	7·13
1899.....	4,402	74·61	8,581	2,829,766	188,349	191,363	1,584,528	8·28
1900.....	1,393	109·68	4,461	3,830,046	256,252	260,352	2,042,361	7·84

Year.	Marble and Stone, and M'f'res of.			Metals, Metal Compositions, and Manufactures of, N.E.S.			Mica, Mineral Substances, and Nickel.		
	Marble and Manufactures of.	Stone and Manufactures of.	Total.	Bronze Manufactures.	All Other.	Total.	Mica.	Mineral Substances N. E. S.	Nickel.
	Value.	Value. (d)	Value.	Value.	Value.	Value.	Value.	Value.	Value.
1896.....	$808,030	$387,979	$1,196,009	$468,884	$3,692,937	$4,161,821	$169,086	$74,395	$32,532
1897.....	860,659	263,381	1,124,040	526,741	3,543,827	4,070,568	159,616	73,373	53,013
1898.....	726,343	229,909	956,252	508,814	3,479,221	3,988,035	150,082	19,160	(f)
1899.....	726,070	200,192	926,262	710,086	4,008,942	4,719,028	275,984	78,453	(f)
1900.....	945,705	246,624	1,192,329	791,306	5,414,508	6,205,814	319,560	71,377	(f)

Year.	Oil, Mineral.				Paints, Mineral. Zinc Oxide in Oil.				Paints and Colors.	Platinum, Man'f'ur'd.
	Gallons.	Liters.	Value.	Value per Liter.	Lb.	Metric Tons.	Value.	Value pr. Met. Ton.	Value.	Value.
1896.....	68,803	260,419	$14,062	$0·054	311,023	141	$14,793	$104·90	$1,189,781	$52
1897.....	949,178	3,592,638	77,789	·021	502,357	228	19,608	86·00	1,319,894	121
1898.....	2,024,090	7,661,808	146,713	·019	27,050	12	2,279	189·92	1,142,670	271
1899.....	1,107,077	4,190,630	103,047	·025	41,699	19	4,154	219·79	1,412,877	876
1900.....	3,039,094	11,503,913	274,766	·024	38,706	18	3,098	176·02	1,491,902	827

Year.	Platinum, Unmanufactured.			Plat'm Vases, Retorts	Potash, Chlorate of.				Potash, Chromate & Bichromate.			
	Kg.	Value.	Val. per Kg.	Value.	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.
1896	2,584·14	$926,678	$358·60	$106,286	4,659,793	2,114	$366,300	$73·27	952,794	432	$80,538	$186·43
1897	2,584·14	960,299	371·61	43,800	6,508,359	2,950	461,630	156·38	1,329,473	603	108,497	179·93
1898	3,142·07	1,178,142	374·96	52,012	4,805,332	2,180	288,965	132·55	1,160,710	526	86,134	163·75
1899	3,027·31	1,482,157	489·59	54,877	1,534,657	696	102,189	146·82	1,130,965	513	73,510	143·29
1900	3,343·90	1,725,206	515·93	35,887	1,253,672	569	68,772	120·93	111,761	51	7,758	153·02

Year.	Potash, Muriate of.				Potash, Nitrate of.				Potash, all other.	
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.
1896.....	88,525,983	40,155	1,392,504	$34·68	20,085,327	9,111	$479,899	$52·67	21,333,884	9,677
1897.....	108,839,049	49,369	1,683,472	34·10	16,276,352	7,383	306,696	41·54	30,311,863	13,749
1898..	103,368,701	46,888	1,620,720	34·57	11,461,823	5,199	281,504	54·15	37,736,761	17,117
1899.....	117,449,708	53,275	1,819,448	34·15	18,961,270	8,601	377,371	43·88	45,322,450	20,558
1900.....	130,174,861	59,047	1,976,604	33·48	10,545,392	4,783	276,664	57·84	54,437,327	24,693

Year.	Potash, all other. *Continued.*		Precious Stones.		Pyrites.				
	Value.	Value per Metric Ton.	Rough & Uncut. Value.	Cut. Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Average Sulphur Contents.
1896	$289,623	$29·93	$78,815	$4,854,358	199,678	202,873	$1,140,571	$5·62	
1897	667,209	48·53	1,425,614	5,090,125	259,546	263,699	874,419	3·32	25%
1898	827,556	48·35	2,550,076	7,388,086	171,879	174,629	544,165	3·12	Over 25%
1899	941,352	45·79	4,955,587	11,653,917	310,008	314,968	1,074,855	3·41	Over 25%
1900	1,399,545	56·68	3,751,219	9,603,164	329,449	334,720	1,089,693	3·26	Over 25%

Year.	Quicksilver.	Salt.				Soda, Nitrate of.			
	Value.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.
1896	$2,037	527,635,090	239,334	$696,197	$2·91	115,504	117,352	$3,566,744	$30·39
1897	20,147	461,813,843	209,479	611,166	2·44	94,965	96,484	2,810,187	29·12
1898	51	374,310,225	169,786	587,348	3·46	147,494	149,854	2,298,240	15·34
1899	83	386,378,938	175,260	587,103	3·35	146,492	149,836	3,486,313	23·42
1900	1,051	415,775,592	188,595	633,192	3·36	182,108	185,022	4,868,520	26·31

Year.	Soda, Bicarbonate.				Soda, Caustic.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1896	4,343,786	1,970	$60,878	$30·90	47,827,247	21,694	$859,809	$39·63
1897	965,669	438	13,982	31·92	57,742,392	26,192	988,318	37·73
1898	280,988	127	5,794	45·62	24,981,873	11,332	354,270	31·26
1899	162,398	74	5,219	70·81	13,363,529	6,062	186,008	30·68
1900	133,137	60	4,509	74·65	8,403,749	3,812	150,530	39·49

Year.	Soda Ash and Sal Soda.				All other Soda Salts.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton
1896	191,780,537	86,991	$1,444,417	$16·60	1,279,285	580	$40,039	$69·03
1897	154,656,060	70,152	1,122,867	16·00	7,927,145	3,596	100,989	28·08
1898	73,064,707	33,142	447,119	13·49	23,354,802	10,594	256,962	24·26
1899	56,053,837	25,426	425,255	16·72	26,340,840	11,948	355,502	29·75
1900	73,815,425	33,482	613,379	18·32	20,351,801	9,231	255,293	27·65

Year.	Sulphur, Crude.				Sulphur, Flowers.				Sulphur, Refined.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896	145,318	147,643	$2,085,076	$14·12	665	675	$13,266	$19·65	447	454	$8,226	$18·11
1897	138,846	141,067	2,442,420	17·31	319	324	7,950	24·54	148	150	3,387	22·58
1898	159,790	162,347	3,081,974	18·98	507	515	14,548	28·25	163	166	4,391	26·45
1899	140,841	143,094	2,494,387	17·43	336	341	9,917	29·08	184	187	4,519	24·17
1900	166,457	169,120	2,918,610	17·26	628	638	17,437	27·32	243	247	6,279	25·43

Year.	Talc.				Tin.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	3,901,314	1,770	$18,693	$10·56	44,639,324	20,248	$5,848,933	$288·86
1897	1,597,849	725	8,423	11·61	55,172,571	25,026	7,415,933	296·33
1898	889,645	404	5,526	13·68	62,748,399	28,462	8,770,221	308·49
1899	508,553	231	3,534	15·32	71,248,407	32,318	16,746,105	518·17
1900	158,497	72	1,070	14·88	69,068,568	31,329	19,458,586	621·10

Year.	Zinc. Block, Pig, and Old. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Manufactures of. Net Value.	Total Value.
1896.....	856,044	388	$25,904	$66·76	$15,728	$41,632
1897.....	2,557,341	1,160	95,883	82·66	19,431	115,314
1898.....	2,742,357	1,244	109,624	88·12	13,448	123,072
1899.....	2,985,463	1,354	151,956	112·23	14,800	166,756
1900.....	2,013,196	913	97,762	107·05	36,836	134,598

(*a*) From *Summary of Commerce and Finance of the United States.* (*b*) Custom-house returns for these years are given in pounds, which are reduced to barrels of 400 lb. for convenience of comparison. (*d*) Including slate. (*e*) Not including ore. (*f*) Not reported.

MINERAL EXPORTS OF DOMESTIC PRODUCTION OF THE UNITED STATES. (*a*)

Year.	Aluminum and Manufactures of.	Asbestos.	Brass & Manufactures of.	Cement.				Chemicals, Drugs and Medicines.	Coal. Anthracite.	
		Value.	Value.	Bbls.	Metric Tons(*m*)	Value.	Value per Met. Ton.	Value.	Long Tons.	Metric Tons.
1896....	(*n*)	(*n*)	$1,026,191	54,839	9,950	$86,757	$8·72	$9,261,354	1,350,000	1,371,600
1897....	(*n*)	$73,736	1,346,802	53,466	9,701	93,684	9·66	9,633,381	1,298,768	1,319,548
1898....	$239,997	54,660	1,237,027	36,732	6,665	73,838	11·08	9,732,734	1,350,948	1,372,563
1899....	291,515	77,409	1,607,072	81,090	14,713	166,073	11·29	11,949,834	1,707,796	1,735,121
1900....	281,821	124,971	2,068,072	100,400	18,216	225,306	12·37	13,765,592	1,662,286	1,688,883

Year.	Coal.—*Continued.* Anthracite.—*Con.*		Bituminous.				Total Long Tons.	Total Metric Tons.	Total Value.	Copper Ore. (*c*)	
	Value.	Val. per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.				Lb.	Metric Tons.
1896	$5,925,506	$4·32	2,276,202	2,312,621	$5,072,818	$2·19	3,626,202	3,684,221	$10,998,324	41,426,560	18,790
1897	5,836,730	4·42	2,399,263	2,437,651	5,326,761	2·19	3,698,031	3,757,199	11,163,491	20,303,360	9,209
1898	5,712,985	4·16	3,152,457	3,202,896	6,699,248	2·09	4,503,405	4,575,459	12,412,233	20,928,320	9,492
1899	7,140,100	4·12	4,044,354	4,109,064	8,573,276	2·09	5,752,150	5,844,184	15,713,376	8,393,280	3,807
1900	7,107,412	4·21	6,255,033	6,355,114	14,416,667	2·27	7,917,319	8,043,996	21,524,079	22,415,680	10,168

Year.	Copper Ore.—*Con.* (*c*)		Copper, Pig, Sheet, and Old.				Copper. Manufactures. Value.	Copper. Total Value.	Earthen, and China Ware.
	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.			Value.
1896.....	$2,393,914	$127·40	259,223,924	111,758	$27,822,280	$248·95	$819,017	$31,035,211	$169,343
1897.....	1,199,029	130·20	277,255,742	125,763	30,627,945	243·54	958,379	32,785,353	207,603
1898.....	755,443	79·59	291,955,905	132,430	33,598,869	253·71	1,190,939	35,545,251	251,821
1899.....	442,868	115·32	246,826,331	111,960	41,190,287	367·90	1,852,499	43,485,654	511,732
1900.....	1,332,829	131·08	338,121,071	153,371	55,291,187	360·51	2,257,563	58,881,529	558,794

Year.	Fertilizers. Phosphates, Crude.				All Other.				Glassware.	Gold and Silver in Coin and Bullion. (*e*)	
	Long Tons.	Metric Tons.	Value.	Value per Met. Tons	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Value.	Gold.	Silver.
1896....	496,168	504,107	$4,537,544	$9·00	(*o*)				$1,115,252	$58,047,269	$63,063,336
1897....	551,046	559,863	5,136,546	9·17	(*o*)				1,234,558	34,174,182	58,352,274
1898....	570,948	580,083	4,672,463	8·05	16,714	16,981	$442,977	$26·09	1,289,919	16,113,258	53,673,605
1899....	867,790	881,675	6,770,102	7·68	49,082	49,867	1,031,882	20·69	1,716,843	45,317,461	53,422,242
1900....	619,995	629,915	5,217,560	8·25	25,976	26,392	537,908	20·38	2,042,633	54,064,697	65,705,909

Year.	Gold and Silver in Ores. (*f*)		Iron Ore.				Iron, Pig.			
	Gold.	Silver.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	$209,621	$993,405	11,016	11,192	$38,916	$3·48	62,071	63,064	$943,022	$14·95
1897.....	102,219	309,018	7,583	7,704	24,612	3·19	262,686	266,889	3,269,010	12·25
1898.....	81,696	123,499	31,579	32,084	67,548	2·11	253,057	257,106	2,702,551	10·51
1899.....	61,950	39,495	40,665	41,316	76,287	1·85	228,678	232,337	3,282,641	14·13
1900.....	69,926	515,755	51,460	52,283	154,756	2·96	286,815	291,404	4,654,582	15·97

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.				Billets, Ingots, and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896	3,505	3,561	$168,680	$47·37	268	272	$12,303	$45·23	(*n*)			
1897	4,493	4,566	150,897	33·05	1,424	1,446	44,754	30·95	6,356	6,458	$108,333	$16·78
1898	7,074	7,188	241,499	33·60	1,593	1,619	58,731	36·28	28,600	29,058	544,771	18·75
1899	10,898	11,073	413,694	37 36	2,869	2,915	117,002	40·14	25,487	25,895	533,241	20·59
1900	13,285	13,498	558,576	41·38	3,021	3,070	138,445	45·10	107,476	109,196	2,915,371	26·70

Year.	Iron, Nails and Spikes, Cut.				Iron Nails & Spikes; Wire, Wrought, Horseshoe and all other, inc. Tacks.				Plates and Sheets of Iron.			
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Metric Ton.
1896	23,708,847	10,754	$458,758	$43·59	9,563,812	4,338	$362,291	$83·51	1,725,779	784	$48,905	$62·37
1897	33,773,216	15,319	670,709	43·78	20,070,024	9,104	550,654	60·49	9,061,447	4,110	175,799	42·77
1898	35,247,266	15,988	641,779	40·20	35,409,739	16,062	839,299	52·25	10,003,903	4,538	204,170	44·99
1899	22,342,543	10,135	482,882	47·64	79,727,846	36,164	1,957,773	54·14	13,880,092	6,296	356,791	56·67
1900	25,004,888	11,342	626,497	55·24	65,434,417	29,681	1,816,823	61·21	20,902,067	9,481	600,600	63·34

Year.	Plates and Sheets of Steel.				Rails or Bars of Iron.				Rails or Bars of Steel.			
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896	4,144,127	1,880	$96,568	$51·37	628	638	$18,581	$28·18	72,503	73,663	1,712,716	$23·30
1897	11,364,821	5,155	173,567	33·66	5,413	5,499	95,520	17·37	142,808	145,093	2,949,901	20·33
1898	60,647,662	27,510	787,245	28·62	8,311	8,444	101,109	11·97	293,592	298,289	5,838,464	19·57
1899	113,422,814	51,448	1,690,490	32·86	6,442	6,545	96,135	14·69	271,272	275,612	6,122,382	22·21
1900	102,040,545	46,285	1,642,944	35·50	5,374	5,460	119,206	21·83	356,245	361,945	10,895,416	30·10

Year.	Structural Iron and Steel.				Wire.				Wire Rods. (Steel.)			
	Long Tons	Metric Tons.	Value.	Val. per Met. Ton	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton
1896	(*n*)				85,216,157	38,655	$1,788,095	$46·23	(*n*)			
1897	15,072	15,313	$604,339	$39·47	118,887,872	53,927	2,353,829	43·65	23,484,969	10,653	$240,737	$22·60
1898	34 038	34,583	1,255,451	36·30	167,252,882	75,865	3,036,818	40·03	41,462,598	18,807	390,144	20·74
1899	54,244	55,112	2,059,289	37·37	260,549,627	118,184	5,526,930	46·83	38,062,438	17,265	524,466	30·38
1900	67,714	68,797	3,570,769	51·90	174,751,242	79,267	4,604,047	58·83	23,860,018	10,823	505,529	46·62

Year.	Lead & Manufactures.	Marble, Stone, & Manufactures of.	Mica.	Nickel. (*g*)	Petroleum (1 = 1,000 in Quantities and total Values.)							
					Crude.				Naphtha.			
	Value.	Value. (*k*)	Value.	Value.	Gallons.	Liters.	Value.	Value per Liter.	Gallons.	Liters.	Value.	Value per Liter.
1896	$601,373	$1,156,051	*Nil.*	$606,833	118,133	447,133	$6,032	$0·013	13.641	51,631	$1,123	$0··021
1897	433,319	1,682,044	*Nil.*	997,391	121,864	461,255	5,044	·011	13,704	51,869	1,020	·020
1898	215,239	1,842,220	$6,272	1,359,609	120,436	455,888	5,016	·011	17,258	65,326	1,071	·016
1899	273,919	1,900,763	4,655	1,151,923	117,690	445,495	5,958	·013	18,210	68,930	1,597	·023
1900	459,571	1,556,981	165	1,382,727	138,166	523,000	7,341	·014	18,570	70,295	1,681	·024

Year.	Petroleum —*Continued.*											
	Illuminating.				Lubricating.				Residue, etc.			
	Gallons	Liters.	Value.	Value per Liter.	Gallons.	Liters.	Value.	Value per Liter.	Gallons (*j*)	Liters.	Value.	Value per Liter.
1896	758,076	3,869,317	$49.704	$0·013	51.705	195.719	$6,771	$0·035	521	1,972	$28	$0·014
1897	804,446	3,044,828	46,876	·015	52,659	199,332	6,732	·034	12,247	46.355	335	·007
1898	764,823	2.895,093	38,895	·013	65,526	248,038	7.626	·031	30,436	115,209	815	·007
1899	733.382	2.776,078	49,172	·018	71.116	269.195	8,658	·032	21.609	81,798	658	·008
1900	739,163	3,104,593	54,693	·018	71,207	269,540	9,933	·037	19,750	74,760	845	·011

Year.	Petroleum.—*Concluded.* Paraffine. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Quicksilver. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Tin Manufactures. Value.
1896	112,517	51·0	$4,563	$89·41	1,525,726	692	$618,437	$895·02	$268,581
1897	136,069	61·7	5,284	85·61	1,007,770	457	394,549	863·35	284,020
1898	166,317	75·4	6,363	84·34	981,497	445	440,587	990·08	281,794
1899	181,861	82·5	7,650	92·74	1,264,372	573	609,586	1,062·92	401,217
1900	157,108	71·2	8,186	114·86	778,191	353	425,812	1,206·61	467,332

Year.	Zinc Ore. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Zinc Oxide. Lb.	Metric Tons.	Value.	Value Per Ton.
1896	4,648,000	2,108	$47,408	$22·49	*Nil.*			
1897	18,502,400	8,393	211,350	25·18	3,718,507	1,687	$104,140	$61·74
1898	23,564,800	10,689	299,870	28·05	7,849,059	3,560	252,194	70·83
1899	56,441,280	25,600	725,944	28·36	10,685,226	4,847	366,508	75·64
1900	81,123,200	38,158	1,133,663	29·71	11,391,693	5,167	496,380	96·06

Year.	Zinc; Pigs, Bars, Plates and Sheets. Lb.	Metric Tons.	Value.	Value per Met. Ton.	All Other Manufactures. Value.	Total Value.
1896	20,300,169	9,208	$1,013,620	$110·08	$51,001	$1,112,029
1897	28,490,662	12,923	1,356,538	104·97	71,021	1,743,0?9
1898	20,998,413	9,525	1,033,959	108·55	138,165	1,724,188
1899	13,509,316	6,128	742,521	121·17	143,232	1,978,295
1900	44,820,915	20,331	2,217,693	109·08	99,288	3,947,024

MINERAL EXPORTS OF FOREIGN PRODUCE FROM THE UNITED STATES. (*a*)

Year.	Antimony. Lb.	Metric Tons.	Value.	Value Per Metric Ton.	Antimony Ore. Lb.	Metric Tons.	Value.	Value Per Metric Ton.
1896	6,951	3·2	$475	$148·44	(*p*)			
1897	4,089	1·9	287	151·55	37,395	17·0	$2,348	$138·12
1898	25,275	11·4	1,729	151·67	34,321	15·6	784	50·26
1899	16,815	7·6	1,275	167·76	*Nil.*			
1900	23,520	10·7	2,352	219·81	*Nil.*			

Year.	Asphaltum or Bitumen (Crude.) Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Brass and Manufactures of. Value.	Cement. Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	113	115	$2,615	$22·74	$3,488	4,437,261	2,013	$16,558	$8·22
1897	40	41	1,042	25·41	3,210	2,488,350	1,129	9,705	8·60
1898	1,514	1,538	28,666	18·64	1,080	6,574 858	2,982	24,283	8·14
1899	1,194	1,213	24,486	20·19	766	11,672,694	5,295	47,384	8·95
1900	629	639	10,044	15·73	2,155	15,815,851	7,174	63,880	8·90

Year.	Chemicals. Salts of Potash. (*h*) Lb.	Kg.	Value.	Value per Kg.	Chloride of Lime. Lb.	Kg.	Value.	Value per Kg.	Nitrate of Soda. Lb.	Kg.	Value.	Value per Kg.
1896	774,452	351,291	$22,333	$0·06	5,500	2,495	$105	$0·04	1,462,720	663,490	$24,254	$0·04
1897	124,277	56,372	4,763	·08	40,916	18,559	718	·04	2,022,720	917,506	33,979	·04
1898	183,804	82,466	5,444	·07	28,605	12,975	381	·03	1,646,400	746,802	24,825	·03
1899	402,230	182,450	12,594	·07	*Nil.*				5,510,400	2,499,501	78,877	·03
1900	809,730	367,291	43,814	·12	148,116	67 185	1,987	·03	6,919,360	3,138,601	112,550	·04

Year.	Chemicals—*Continued.*											
	Caustic Soda.				Sal Soda and Soda Ash.				All Other Salts of Soda.			
	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.
1896	1,703,173	772,559	$33,433	$0·04	470,102	213,238	$4,098	$0·02	36,839	16,710	$380	$0·02
1897	1,824,565	827,623	34,332	·04	2,246,181	1,018,868	9,128	·01	20,797	9,433	262	·03
1898	1,237,257	561,216	22,202	·04	4,247,945	1,926,855	14,255	·01	120,542	54,677	1,400	·03
1899	1,032,831	468,489	18,330	·04	1,173,781	532,424	4,193	·01	93,520	42,420	2,035	·05
1900	1,139,954	517,080	24,228	·05	78,017	35,388	1,126	·03	270,307	122,610	2,788	·02

Year.	Clays or Earths of All Kinds, including China Clay.				Coal, Bituminous.				Copper.			
									Ore and Regulus.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.
1896	32	33	$109	$3·30	5,204	5,287	$7,990	$1·51	1,075,200	488	$32,715	$67·04
1897	16	16	63	3·93	5,297	5,382	6,337	1·18	1,328,320	603	85,170	141·24
1898	91	92	657	7·11	2,890	2,936	2,675	0·91	7,622,720	3,458	547,960	158·46
1899	152	154	1,304	8·44	6,806	6,915	9,598	1·39	3,841,600	1,743	265,326	152·22
1900	78	79	572	7·22	6,740	6,848	19,740	2·88	2,159,360	979	170,191	173·75

Year.	Copper.—*Continued.*					Earthen, Stone, and China-ware. Value.	Fertilizers.			
	Pigs, Bars, Ingots, Old, and Other Unmanufactured.				Manufactures. Value.		Guano.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	*Nil.*				$7,307	$28,267	26	26	$657	$25·27
1897.....	406,598	184	$30,167	$163·93	4,225	23,438	*Nil.*			
1898.....	23,647,968	10,727	1,437,464	134·00	4,637	30,646	*Nil.*			
1899.....	2,550,149	1,157	350,919	303·30	10,250	38,393			8	
1900.....	1,281,782	581	212,264	365·19	21,032	38,008	*Nil.*			

Year.	Fertilizers—*Continued.*					Glass and Glassware.	Graphite.			
	Phosphates, Crude or Native.				Other Fert'z's					
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Value.	Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1896.....	*Nil.*				$1,111	$13,761	6	6	$296	$46·00
1897.....	65	66	$1,782	$27·00	3,482	15,579	128	130	7,393	56·87
1898.....	10	10	306	30·12	13,499	13,805	165	168	11,645	69·32
1899.....	723	735	8,718	11·87	4,510	11,179	5	5	338	67·60
1900.....	75	76	386	5·07	31,716	14,614	3	3	115	37·72

Year.	Iron and Steel, and Tin Plate.											
	Pig Iron.				Scrap Iron and Steel, fit only to be remanufactured.				Bar Iron, Rolled or Hammered.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	599	609	$12,220	$20·06	240	244	$2,160	$8·85	19,107	9	$610	$67·77
1897	114	116	1,394	12·00	57	58	313	5·40	66,345	30	1,699	56·60
1898	581	590	7,098	12·03	63	64	270	4·22	48,151	22	1,648	74·91
1899	597	607	7,908	13·04	195	198	2,671	13·49	85,630	39	3,159	81·42
1900	151	153	5,410	35·26	9,079	9,224	131,241	14·23	158,784	72	2,447	33·99

Year.	Iron and Steel, and Tin Plate.—*Continued.*											
	Railway Bars of Iron or Steel, or in Part of Steel.				Ingots, Blooms, Slabs, Billets and Bars of Steel, and Steel in Forms, N. E. S.				Sheet, Plate and Taggers, Wire Rod, Wire, and Wire Rope and Strand, Iron or Steel.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1896	*Nil.*				*Nil.*				3,102,098	1,407	$46,381	$32·96
1897	262	266	$11,921	$44·82	15,515	7	$1,728	$246·86	2,446,012	1,109	68,878	62·11
1898	140	142	3,479	24·50	100,417	46	3,829	83·24	824,733	374	21,231	56·77
1899	*Nil.*				10,769	5	1,718	350·61	377,402	171	11,148	65·12
1900	*Nil.*				5,319	2	1,342	559·17	468,790	213	11,599	54·56

Year.	Iron and Steel, and Tin Plate—*Concluded.*					Lead and Manufactures of. Value.	Marble and Stone and Manufactures of. Value. (*k*)	Metal Compositions and Manufactures. Value.
	Tin Plates, Terne Plates, and Taggers Tin.				Manufactures. Value.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.				
1896	1,674,187	760	$40,920	$53·84	$114,472	$1,504,937	$14,227	$43,757
1897	2,951,473	1,339	79,179	59·21	165,710	2,088,923	15,156	32,791
1898	899,757	408	22,271	54·59	279,717	2,599,734	5,452	58,810
1899	378,866	172	11,308	65·82	346,795	2,881,641	7,525	57,050
1900	1,038,694	471	37,395	79·39	328,704	3,841,238	5,721	79,218

Year.	Oil, Mineral.				Paints and Colors. Value.	Precious Stones. Value.	Salt.			
	Gallons.	Liters.	Value.	Value per Liter.			Lb.	Met. Tons.	Value.	Value per M. Ton.
1896	*Nil.*				$23,703	$18,979	7,038,134	3,192	$14,947	$4·68
1897	*Nil.*				15,473	26,698	5,074,995	2,302	10,189	4·43
1898	3,219	12,185	$486	$0·04	15,854	39,974	4,827,288	2,189	4,751	2·17
1899	150	568	38	·07	12,104	49,256	5,216,112	2,366	9,858	4·17
1900	4,706	17,814	800	·04	13,814	14,189	3,548,724	1,610	3,907	2·43

Year.	Sulphur or Brimstone (Crude).				Tin, in Bars, Blocks, Pigs, Grain or Granulated.				Zinc and M'f'res
	Long Tons.	Met. Tons.	Value.	Value per M. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Value.
1896	484	492	$8,535	$17·34	289,266	131	$41,874	$319·64	$215
1897	194	197	3,982	20·20	869,929	395	118,882	300·97	2,291
1898	1,414	1,437	31,822	22·14	740,326	336	113,334	337·30	1,536
1899	477	485	10,804	22·29	999,315	453	265,188	585·02	1,604
1900	540	549	13,495	24·60	1,108,124	503	335,377	667·28	3,048

(*a*) From *Summary of Commerce and Finance of the United States.*
(*c*) Ore, so called, consisting chiefly of matte.
(*e*) Total exports of coin and bullion; that is, includes both domestic and foreign not elsewhere specified.
(*f*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte which is classified as copper ore and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin.
(*g*) Including nickel oxide and matte.
(*h*) Includes chlorate, muriate, and nitrate of potash, and all other salts of potash.
(*j*) Reported in bbls. and reduced to gals. at 42 gals. = 1 bbl.
(*k*) Including slate.
(*m*) Calculated at 1 bbl. = 400 lb.
(*n*) Not enumerated.
(*o*) Not reported separately. Included with crude phosphates.
(*p*) Not reported separately. Included with antimony.

NOTE.—N. E. S. signifies not elsewhere specified.

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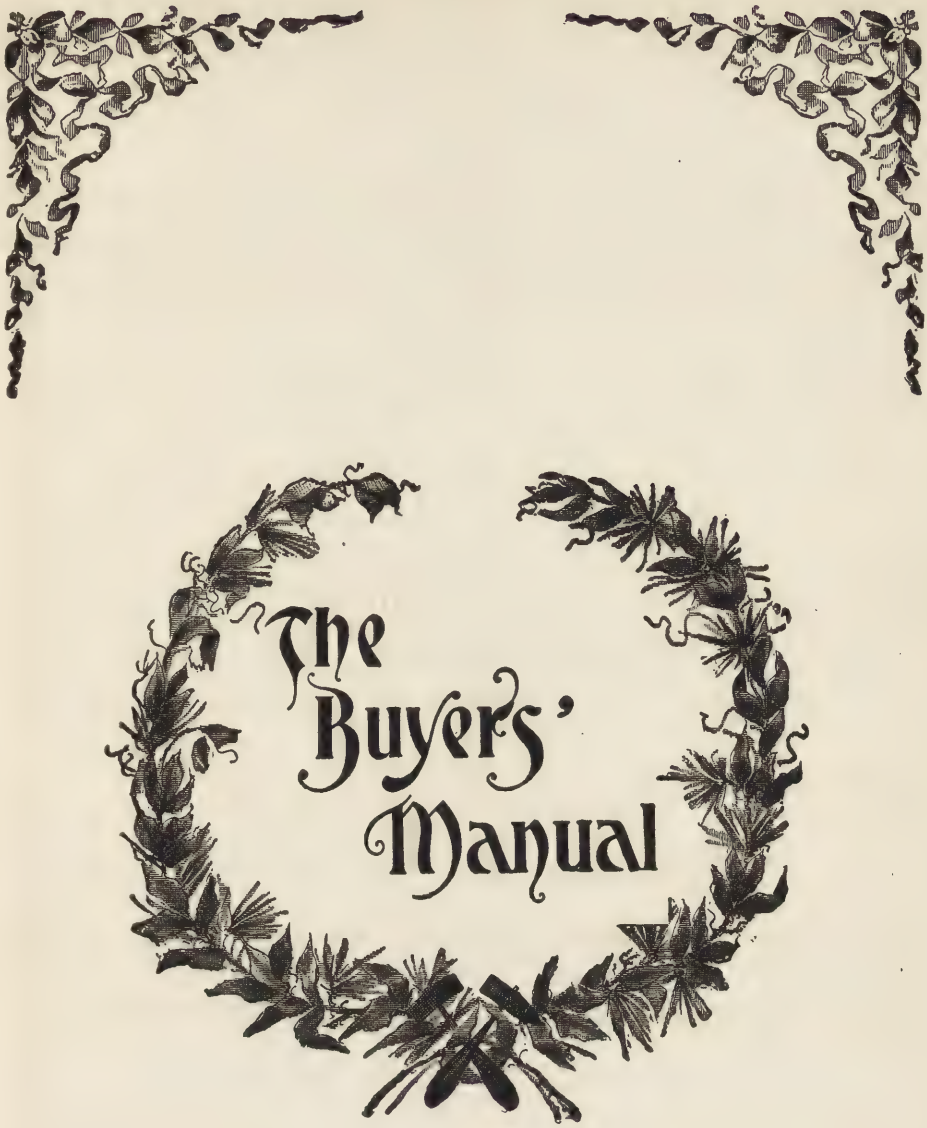
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The
Buyers'
Manual

Preface.

THE advertising pages of the annual volumes of this work will well repay the careful perusal and study of every reader who wishes to be well informed upon the present condition of the mineral industry. They give an admirable and practical insight into the present state of the mining and metallurgic arts, for in them nearly every manufacturer or dealer of note in this country advertises the machines, appliances, and processes which are now in vogue, or which it is sought to introduce; while the names and specialties of the most eminent members of the engineering professions, as indicated in their cards, show the direction of modern mining and metallurgical progress.

These advertising pages are no less important to those who desire a clear knowledge of the means by which this country has come to be far the most important producer of minerals and metals than to those who wish to know where to get that full and reliable information concerning the values of properties, machinery, processes, and products which should precede the investment of capital.

Every country in the world is wisely striving to develop its mineral resources, and to build up its mineral industry, and in all of them this volume, which gives the latest and best practice in every department of the industry, has become indispensable. It is constantly consulted for the best technical skill and the most advantageous machinery and appliances in use. All enterprising manufacturers of such wares appreciate this fact, and know that in no other way can they so effectively bring their goods before those who may need them as through the advertising pages of THE MINERAL INDUSTRY. These pages have become a veritable directory of the best in everything relating to the industry, and American, German and English manufacturers there compete for the orders of the whole world. $1,000,000,000 a year is certainly not an overestimate of the annual expenditure for technical skill, machinery and supplies used in the industry of which THE MINERAL INDUSTRY and *The Engineering and Mining Journal* are not only the chief but the only universal representatives published in any language.

The Publishers.

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A BIT OF BOOK TALK...

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Buyers' Manual of the Mineral Industry

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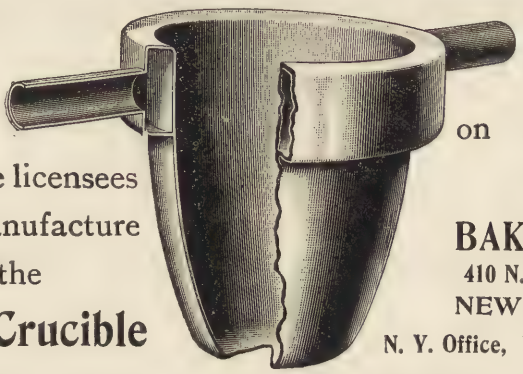
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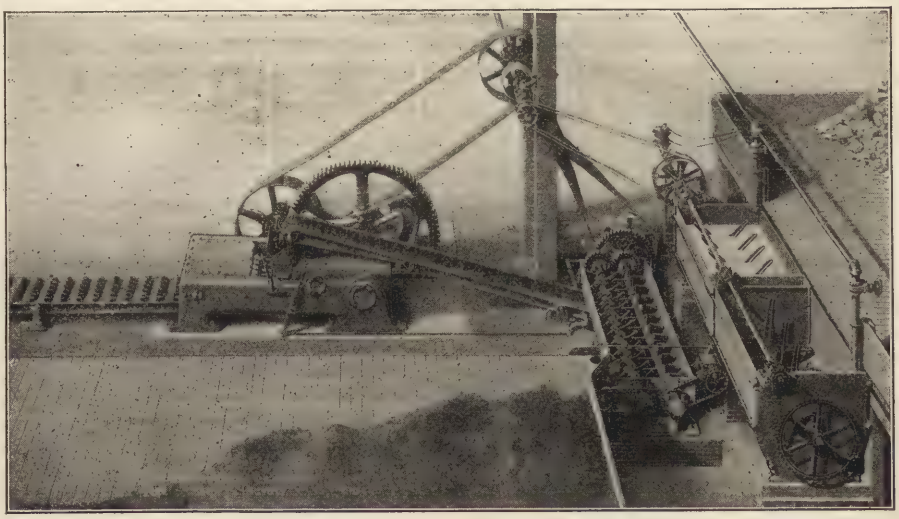
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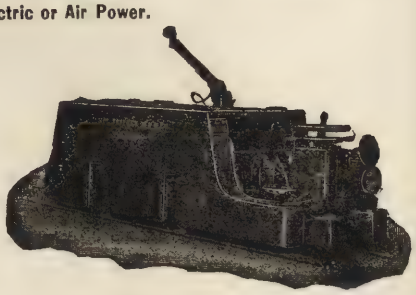
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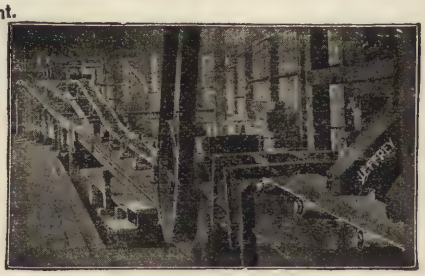
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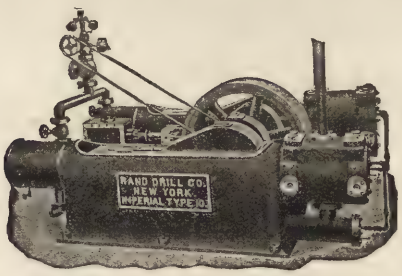
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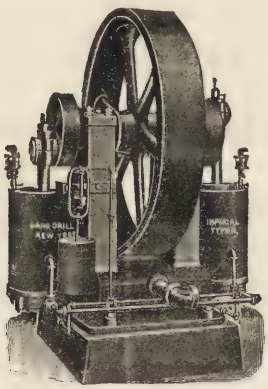


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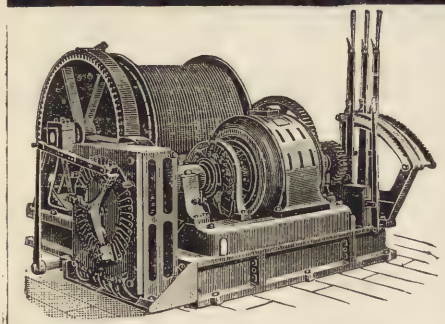
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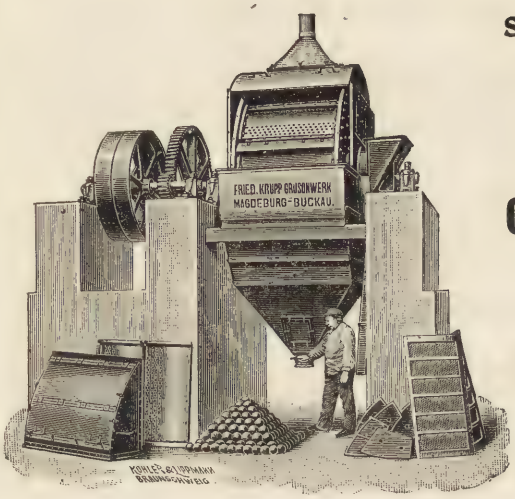
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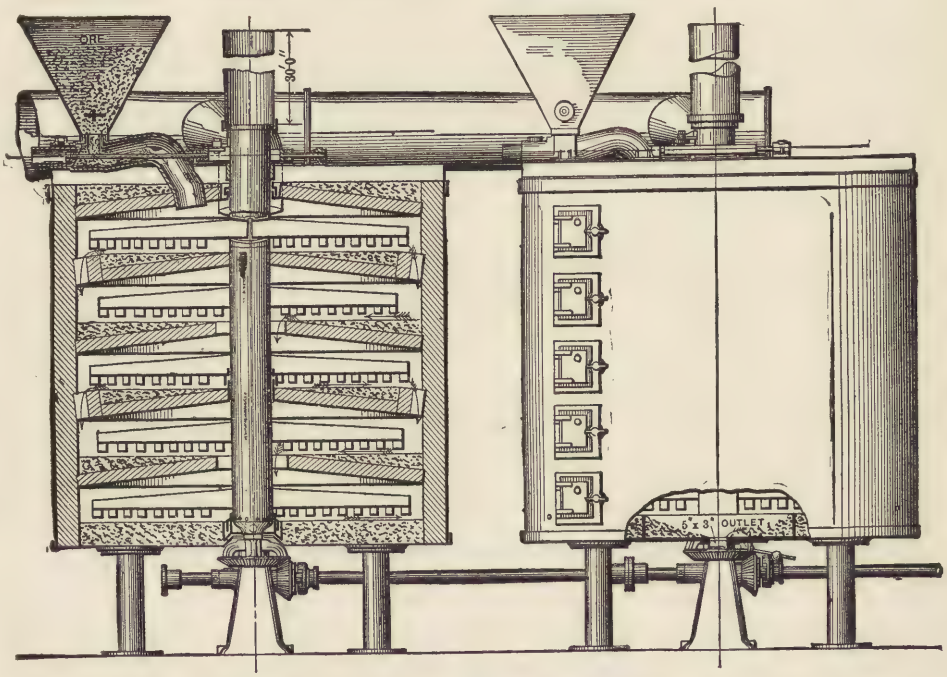
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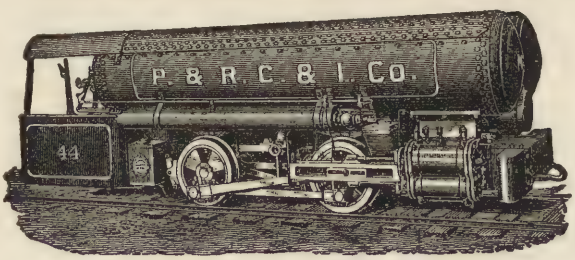
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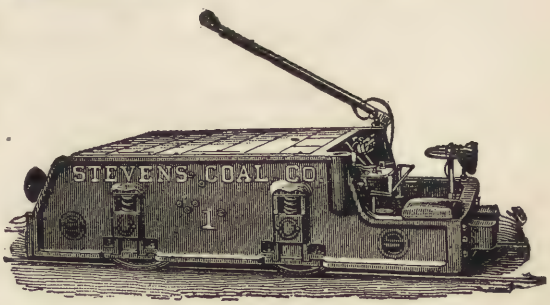
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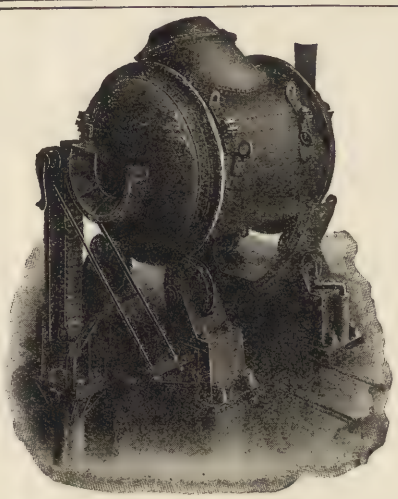
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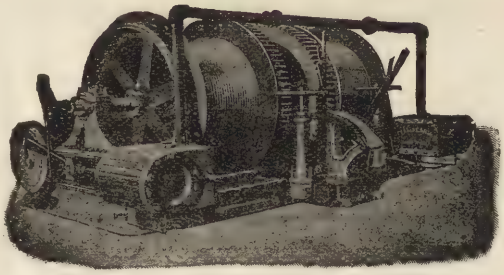


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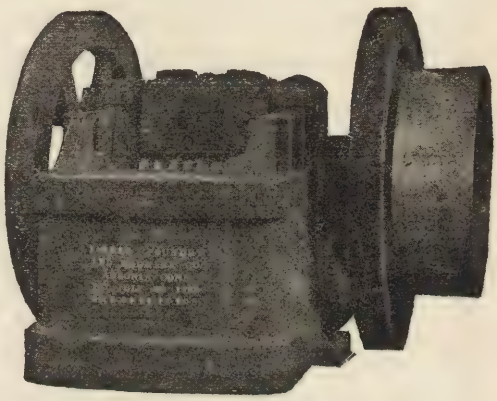
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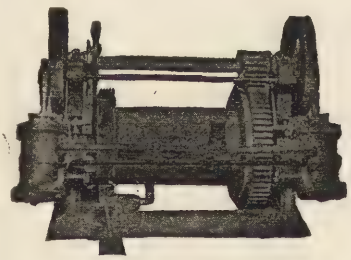
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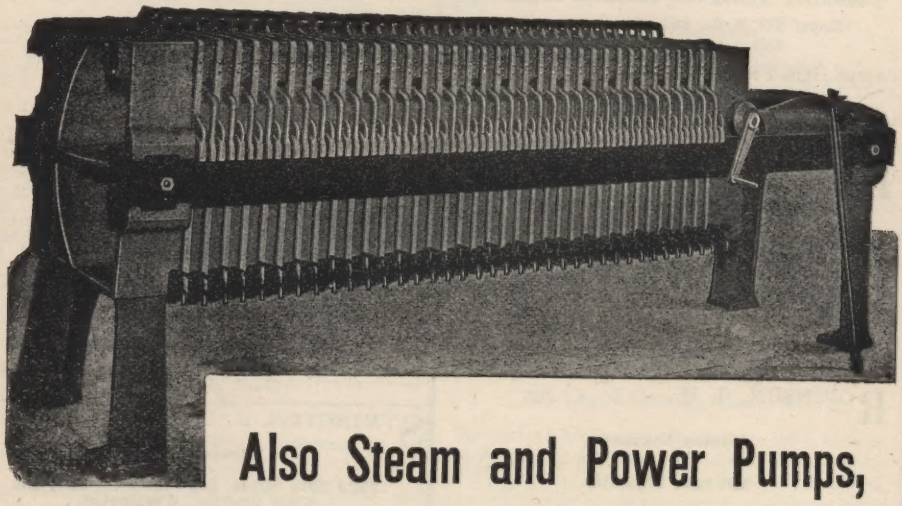
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